ASTRONOMY

March 1985

U.S. $2
UK £1.35
Can. $2.50

Comet Countdown

Nemesis: Fact or Fancy?

Learn the Southern Stars

ICD# 08070

The 14th Flight of the Shuttle

Meade® Quartz S/C's:

Meade
QUARTZ
Meade
N
E
W
S
Quartz
Manual
Sidereal
Solar
Lunar
Drive
Corrector
Power
12V. D.C.
Reticle
Map
Dec
Reticle
Adjust
Meade
QUARTZ
LX DRIVE

The Quantum Leap.

Meade 8" Model 2080/LX3 and 10" Model 2120/LX3, with Quartz Electronic Drive Systems: the most advanced Schmidt-Cassegrains ever manufactured for the serious amateur. Consider these state-of-the-art features:

1 Certified Optics: All 8" and 10" LX3 optics are hand-matched, laser-tested, and individually certified in writing by Meade Instruments to yield the finest diffraction-limited Schmidt-Cassegrain performance obtainable from any manufacturer.

2 New Quartz Electronic LX Drive System: Ultraprecise quartz micro-electronics augment the superb Meade LX Worm Gear Drive, to achieve *true sidereal-rate tracking.* Input-frequency is accurate within ± .005% of the sidereal frequency, *independent* of ambient temperature and local power line frequency variations.

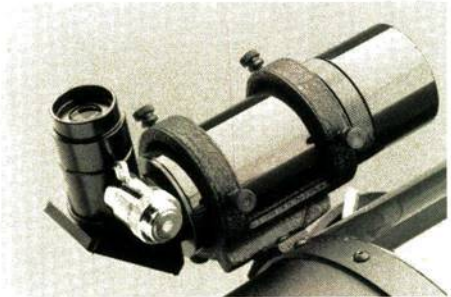
3 Plug-In Single- or Dual-Axis Drive Corrector Capability: No drive corrector chassis boxes to fool with! All electronics are completely self-contained within the LX3 drive base — just plug-in the optional R.A. or Dual Axis control box and use. In the Dual-Axis mode, the Declination motor plugs directly into a jack on the LX3's power panel.

4 A.C. Operation: A 25-ft. power cord with self-contained 115 volts A.C. converter is included with each 8" and 10" LX3 model, yielding 12 volts D.C. input to the telescope's power panel. A red L.E.D., located adjacent to the power input jack, indicates proper power connection.

5 Field Operation: Meade LX3 models operate from 12 volts D.C. and may be powered *directly* from your auto cigarette lighter plug, using the standard-equipment D.C. power cord — *no drive corrector or inverter unit is required for field operation!* LX3 models may even be independently powered in the field, away from your automobile, with the optional Meade Power Cell.

6 Power Panel Output Jacks: The Meade 12mm Illuminated Reticle Guiding Eyepiece and red L.E.D. Map Light plug directly into jacks provided on the power panel, eliminating the need for separate battery packs.

7 8 x 50mm Illuminated Reticle Polar Viewfinder: The illuminated, precisely-etched reticle scale permits extremely accurate polar alignment.



8 x 50mm Polar Viewfinder: with illuminated-reticle and self-contained L.E.D. battery pack.

The Meade 8" Model 2080/LX3: The next generation S/C from the World Leader.

8 Equatorial Wedge with Magnetic Compass, Latitude Scale, Bubble Level, and Micrometric Azimuth Control: This Meade exclusive facilitates *fast, easy* polar alignment even if the Pole Star is not visible from your observing location.

9 Piggyback Camera Bracket: This useful accessory, again included with all LX3's, attaches directly to the telescope's rear cell, for wide-field astrophotography using your 35mm camera.

10 Multi-Coated Diagonal Prism: The Meade Multi-Coated diagonal yields the highest light transmission (over 98%) of any production diagonal available, mirror or prism.

11 High Transmission (MgF_2) Coatings on the Correcting Plate: These coatings substantially increase correcting plate light transmission throughout the visual spectrum.

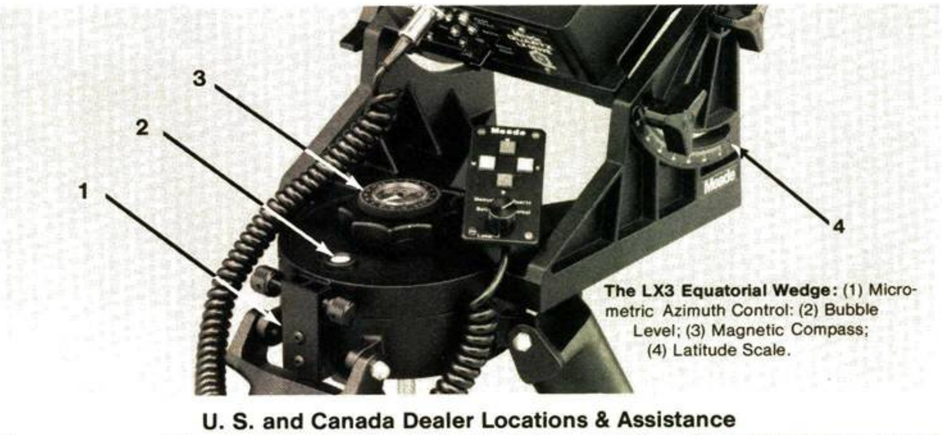
12 Optional Multi-Coated/Silvered Optics Group: *The revolutionary MC/SO Group achieves virtual maximization of transmission/reflectance on every optical surface, and increases total light transmission by approximately* **23%** *over standard Meade 8" and 10" Schmidt-Cassegrains.* The Group includes (1) Multi-Coated aluminized primary mirror; (2) Multi-Coated silvered secondary mirror, in place of standard-aluminized mirrors; and (3) Multi-Coated correcting plate in place of standard MgF_2 coatings (item 11 above).

13 Audio Cassette: This useful tape, provided with every LX3 telescope, explains in detail the features, set-up, and applications, both visual and photographic, of your telescope.

14 Lifetime Warranty: Meade 8" and 10" LX3 Schmidt-Cassegrains, excluding batteries, *are warranted for life* in the U.S.A. and Canada. See the Meade General Catalog for details on this warranty — the most extensive in the industry.

The best news of all . . . Meade LX3's are priced competitively with other Schmidt-Cassegrains offering only a fraction of the LX3 features. Discover them now at your Meade dealer. You'll see why Meade Instruments is the World's leading manufacturer of astronomical telescopes for the serious amateur.

And the first to make a true Quantum Leap in Schmidt-Cassegrain technology.



The LX3 Equatorial Wedge: (1) Micrometric Azimuth Control: (2) Bubble Level; (3) Magnetic Compass; (4) Latitude Scale.

U. S. and Canada Dealer Locations & Assistance

For your nearest Meade dealer location, or for free telescope information and assistance, call Meade Instruments **toll-free** from anywhere in the continental U.S.A, (except Calif.):

1-800-854-7485

From all other areas, including California, call direct: **(714) 556-2291**

Complete 52-Page General Catalog - $3.00

Send $3.00 for your copy of the Meade full-color **General Catalog #85C,** with many astrophotos through Meade telescopes and complete details on the entire range of Meade precision astronomical telescopes, spotting scopes, telephoto lenses, and accessories. Meade General Catalogs are forwarded by return First Class Mail.

Meade Instruments Corporation
1675 Toronto Way, Costa Mesa, Calif. 92626 ☐ (714) 556-2291

© 1985

ASTRONOMY

Vol. 13, No. 3 March 1985

The World's Most Beautiful Astronomy Magazine • Established by Stephen A. Walther

Editor-in-Chief
Richard Berry
Managing Editor
Katherine Bond
Art Director
Thomas L. Hunt
Senior Editor
Robert Burnham
Assistant Editors
David J. Eicher
Francis Reddy
Assistant Art Director
Jane Borth Lucius
Typographer
Mary MacAdam
Art Assistant
Susan R. Myers
Editorial Assistant
Diane Kendzie-Holdaway

President, AstroMedia Corp.
Robert A. Maas
Advertising Coordinator
Dana-Lynne Terry
Accountant
J.L. Peters
Product Manager
Susan Poole
Circulation Director
Kristie Fischer
Circulation Manager
Rosemary L. Pickart

Adv. Rep., NE Region
Adpress, Inc.
New York, NY 10016
(212) 679-1710
U.S. Newsstand Distribution
I.C.D., The Hearst Corp.
New York, NY 10019
Canadian Newsstand Dist.
Distr. Div. of TV GUIDE
Toronto, Ontario M4S 3B3
World Newsstand Distribution
Boarts International, Inc.
New York, NY 10019

6 Comets: Keys to Our Solar System
by Debra Meloy Elmegreen

12 The Return of Halley's Comet

18 Comets, "Death Stars," and Extinctions
by Ray Grasshoff

Forum 24 Planetary Astronomers Meet in Hawaii

In Focus 32

Behind the Scenes 33

Gazer's Gazette 34 Stars of the Circumpolar South
by David J. Eicher

Astronomy Reviews 39

Eye on the Sky 42 Venus' Dramatic Exit
by Fred Schaaf

Photography in Astronomy 51 Making an Astrophotographic Mosaic
by Robert Reeves

AstroNews 60

AstroCalendar 64

AstroMart 65

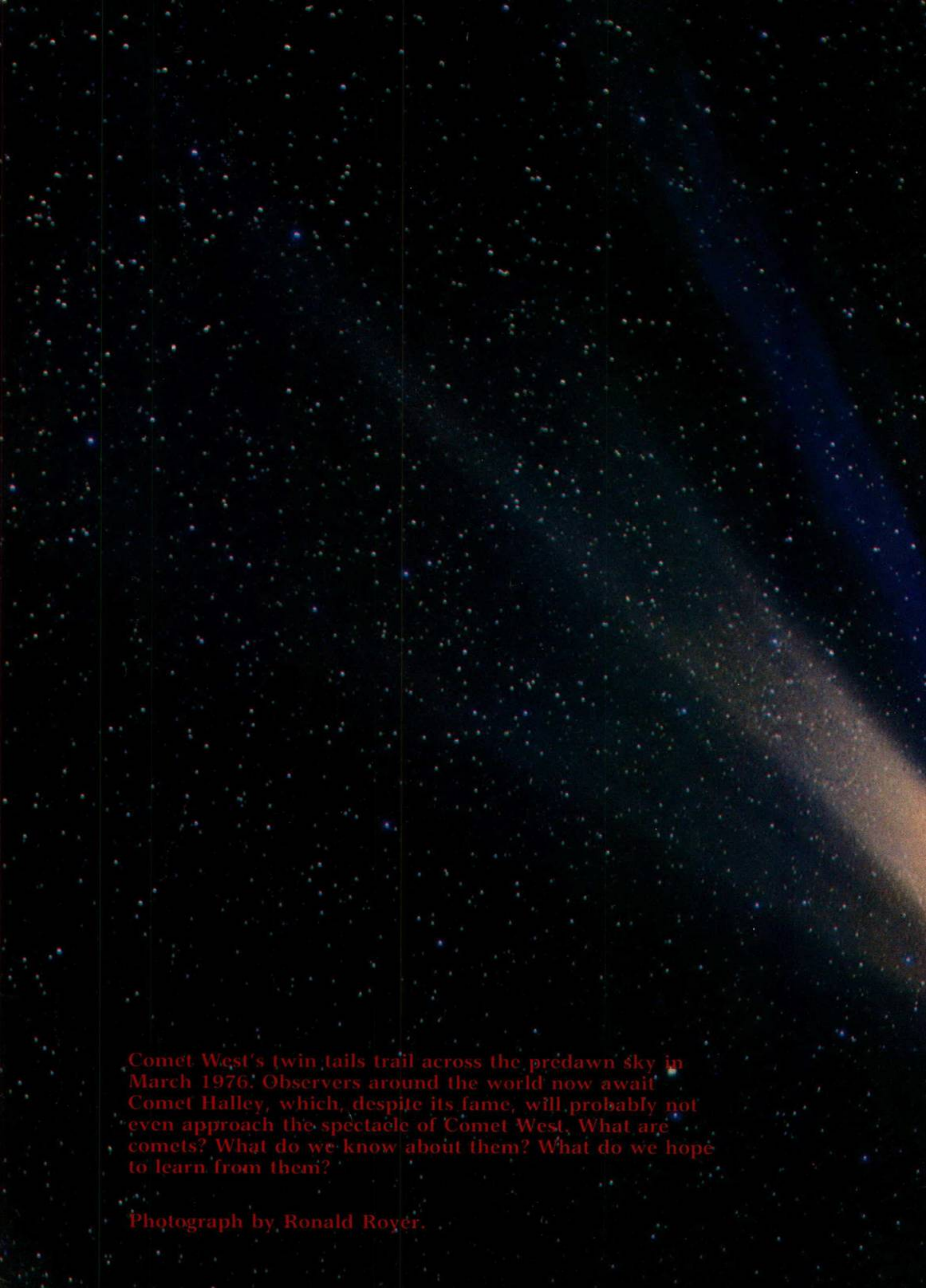
Stellar Frontiers 66 Earth, Water, Sky: The 14th Flight of the Shuttle

Equipment Atlas 76 Build a Simple Folded-Refractor Telescope
by Steve Edberg

The Backyard Astronomer 78 Cancer

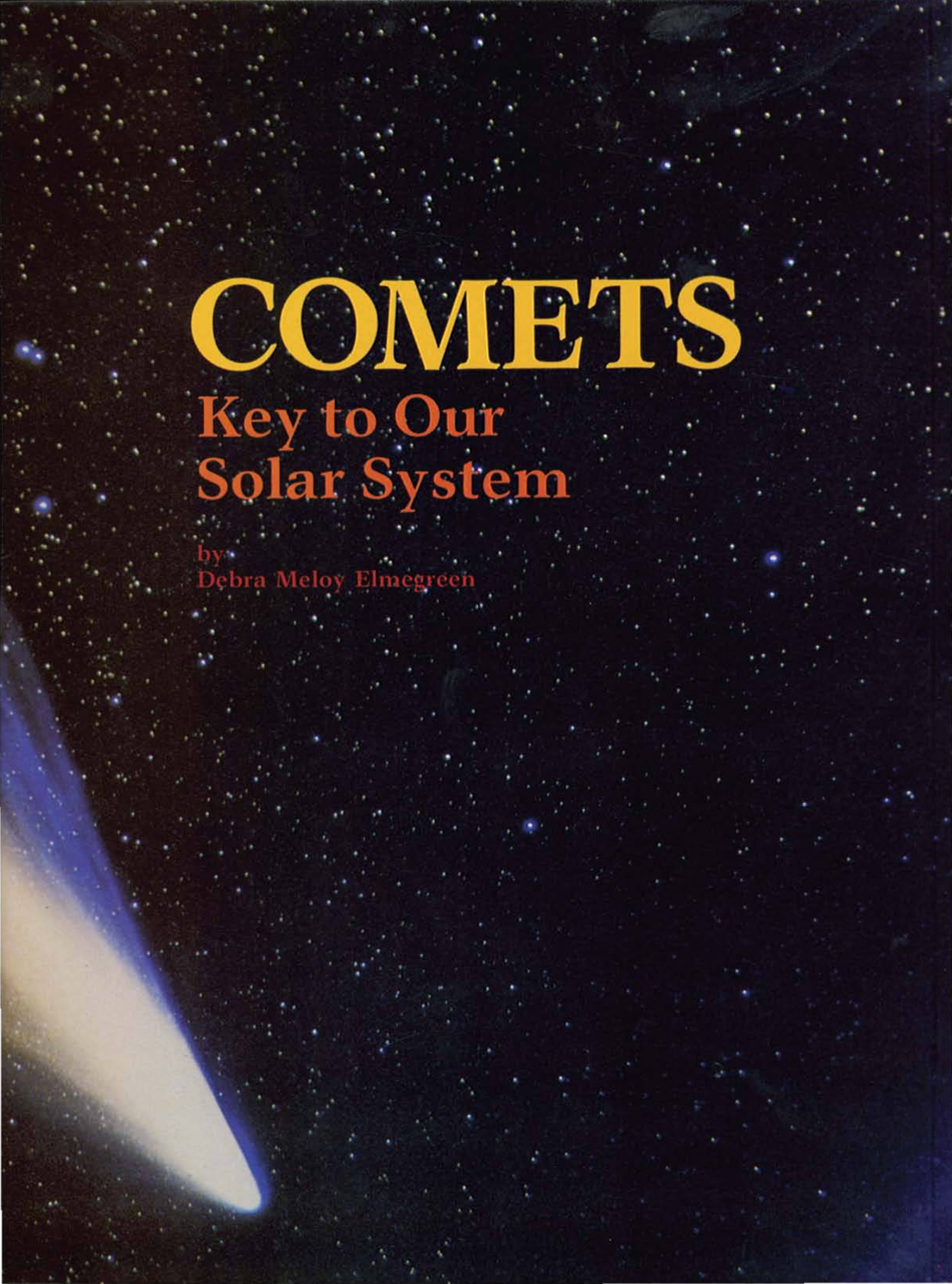
Cover: Astronaut Dale Gardner, preparing to recover a malfunctioning communication satellite, clings to Discovery's starboard side during the 14th Shuttle flight (frame S19-104-046). This month, ASTRONOMY delves into the realm of comets — flimsy "dirty snowballs" that hold secrets of the early solar system. Then we take a critical look at the controversial "Nemesis" theory — Do periodic comet showers impact on Earth and exterminate life? These pages: Giant cumulus clouds tower into a setting Sun over Argentina and Paraguay (frame S19-38-109). NASA photos.

ASTRONOMY (ISSN 0091-6358) is published monthly by AstroMedia Corp., 625 E. St. Paul Ave., P.O. Box 92788, Milwaukee, WI 53202.
Copyright © 1985 AstroMedia Corp., all rights reserved. Material in this publication may not be reproduced in any form without permission.
Second class postage paid at Milwaukee, WI and additional mailing offices. POSTMASTER: Send address changes to ASTRONOMY, P.O. Box 92788, Milwaukee, WI 53202. Questions about subscriptions and product orders: **(414) 276-8547** weekdays, 8am - 4pm. Allow six to eight weeks for new subscriptions and changes of address. New subscriptions start with current issue. Subscription price: 1 year, $21.00. All foreign: add $5.00 per year; please remit in U.S. funds. Send editorial and business inquiries and submissions to the address above. Telephone: (414) 276-2689. Not responsible for unsolicited materials. AstroMedia staff: Patricia Adams, Sherrie Burns, Mercy Domena, Merlene Edwards, Wendy Graika, Erica Jensen, Maggie Martinez, Susan Robinson, Sandy Timmons, Deborah Wicentowski. ASTRONOMY is indexed in *The Reader's Guide to Periodical Literature*. Microfilms of ASTRONOMY available from University Microfilms, Inc., 300 N. Zeeb Rd., Ann Arbor, MI 48106 and Bell & Howell Company, Old Mansfield Rd., Wooster, OH 46691. Printed in the U.S.A.



Comet West's twin tails trail across the predawn sky in March 1976. Observers around the world now await Comet Halley, which, despite its fame, will probably not even approach the spectacle of Comet West. What are comets? What do we know about them? What do we hope to learn from them?

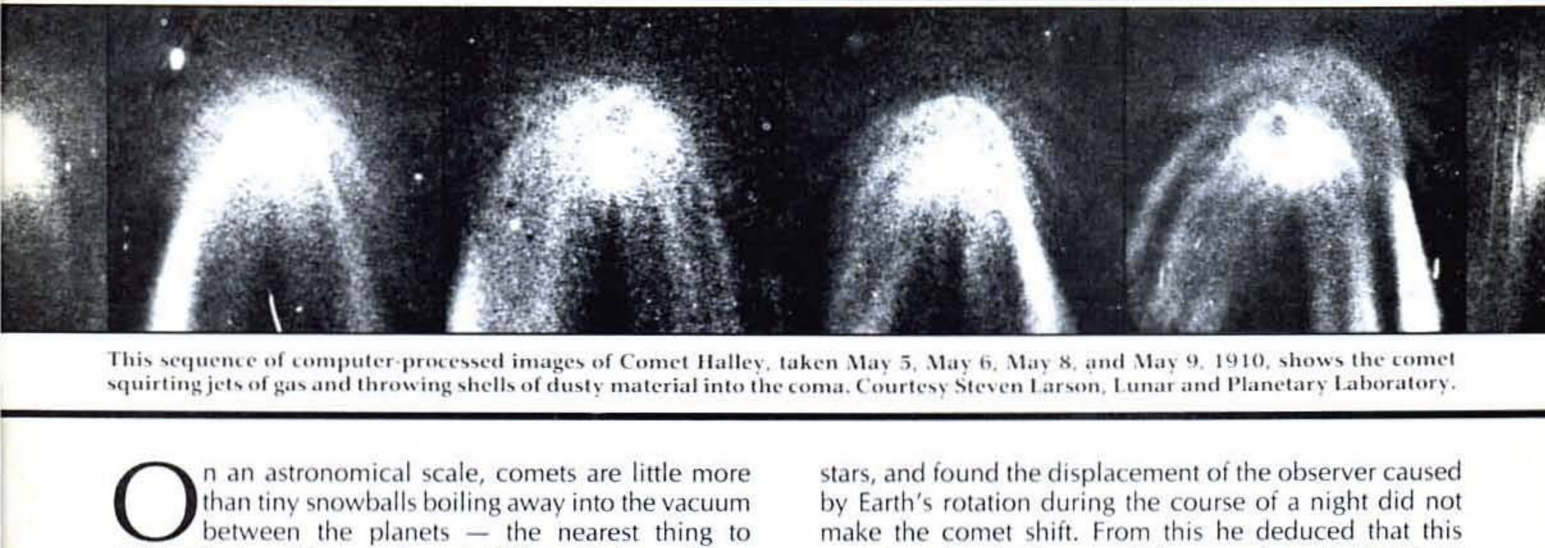
Photograph by Ronald Royer.



COMETS

Key to Our Solar System

by
Debra Meloy Elmegreen



This sequence of computer-processed images of Comet Halley, taken May 5, May 6, May 8, and May 9, 1910, shows the comet squirting jets of gas and throwing shells of dusty material into the coma. Courtesy Steven Larson, Lunar and Planetary Laboratory.

On an astronomical scale, comets are little more than tiny snowballs boiling away into the vacuum between the planets — the nearest thing to nothing that anything can be and still be called something. A comet's tail may extend over one hundred million miles — enough to span the gap between Earth and the Sun — but it's made of gases far more rarefied than the best laboratory vacuum. Despite their evanescence, comets may hold vital keys to unlocking the mysteries of the solar system, and may have even affected the course of life on Earth.

Of course, this is the year to be thinking of comets with Comet Halley now on its way back to our part of the solar system — and because they know it's coming, astronomers are getting ready to study Halley more intensively than any previous comet.

The comet we now call Halley has been observed for at least three thousand years. It is probably the same comet observed in 1057 B.C. by Chinese astrologers. Other ancient astronomer-priests probably sighted Halley in 613 B.C., 466 B.C., and 240 B.C. However, the first really well-established sighting of Halley is that of 87 B.C., when Julius Caesar was a boy of 14.

Throughout much of the time humans have observed them, comets have been regarded as omens. Halley is no exception. As the Danish army under William of Normandy defeated the English at the Battle of Hastings in 1066, Comet Halley blazed across the sky. Since cometary bad luck was assumed to fall upon the current ruler, the portent could be either good or bad, depending on the loyalties of the viewer!

Because of this, comets have influenced the course of history. Court astrologers to Queen Elizabeth I advised her not to view the bright Comet of 1577. Being curious and brave, she looked anyway. Elizabeth supposedly exclaimed, "The die is cast!" when she saw it — and went on to defeat the Spanish Armada. Elizabeth, a direct descendant of William, had a family history of cometary assists.

The Comet of 1577 was also observed by the Danish astronomer Tycho Brahe. Tycho was one of the first to make accurate positional measurements on comets. He measured the comet's position against the background stars, and found the displacement of the observer caused by Earth's rotation during the course of a night did not make the comet shift. From this he deduced that this comet, and probably comets in general, are farther from Earth than the Moon. This placed comets among the planets, laying to rest the belief that comets are atmospheric phenomena like meteors, lightning, and the northern lights. The King of Sweden, a progressive man, was pleased by Tycho's work and rewarded him with an observatory, named Uraniborg, situated on the island of Hven in the Baltic Sea between the coasts of Sweden and Denmark. Tycho became one of history's greatest astronomers and laid the observational framework from which Johannes Kepler discovered the laws of planetary motion. Kepler, heir to Tycho's observations, observed Comet Halley in 1607. He incorrectly deduced that comets move in straight lines, though he *was* correct in realizing that cometary orbits are often less curved than the near-circular paths of the planets.

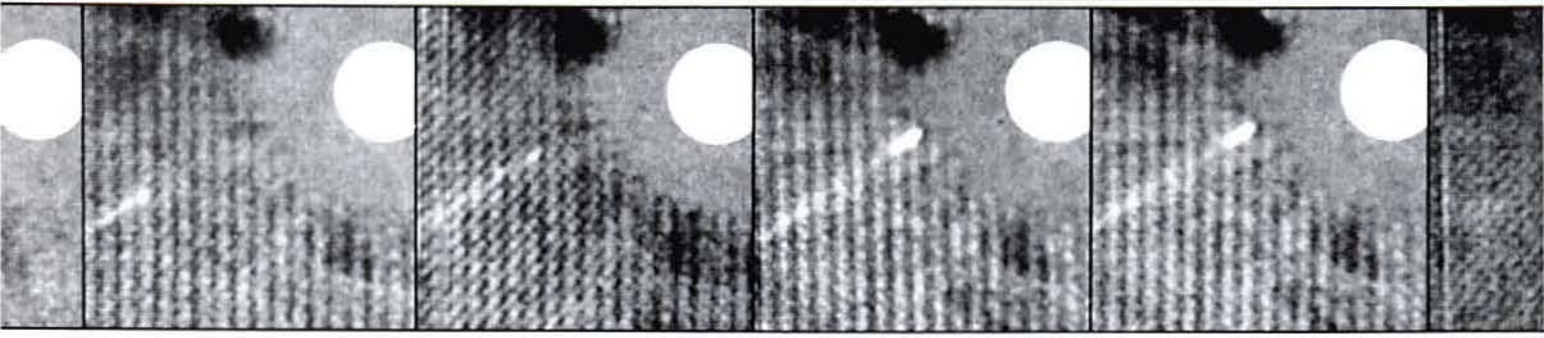
Edmond Halley and Isaac Newton, who were friends, also viewed the 1607 comet that would later bear Halley's name. Newton, then in the process of developing his laws of gravitation, reasoned that comets must move under the influence of gravity as do the planets, so they should follow paths that are conic sections — parabolas, ellipses, or hyperbolas. Halley then analyzed the orbits of 24 recorded comets and determined that they were ellipses.

He noticed that three of the comets had nearly the same orbit, however, and wondered if they might be one and the same. If this were the case, the comet had appeared at intervals of roughly 75 years, so he predicted the date of its next return. The comet Halley "discovered" bears his name today. Halley's prediction that the comet would return in 1758 was correct, though he did not live to see it.

Edmond Halley's bold prediction was a spectacular confirmation of Newtonian physics — and the first time in history that anyone had successfully predicted the return of a comet. Since then, Halley's Comet has returned twice — in 1835 and again in 1910. And in less than a year, we will have the opportunity to view Halley's Comet.

This time, as at previous apparitions, astronomers competed to be the first to recover the returning comet. The winners, graduate student David Jewitt and G. Edward Danielson, a staff astronomer from the California Institute of Technology, found Halley on October 16, 1982 — more than three years before it is due to pass closest to the Sun. Observing with the 200-inch telescope on Palomar Mountain with an ultrasensitive CCD camera, they discovered a small object with an apparent

In 1910, astronomers at the Helwan Observatory in Egypt recorded Comet Halley on the slow, fine-grained photographic plates of that era. Astronomers today are studying these three-quarter-century-old images in hopes of predicting what Halley will do at its 1986 apparition. Courtesy International Halley Watch.



Comets occasionally crash into the Sun. An eight-hour sequence of 1981 satellite images shows an unnamed comet disappearing into the Sun. The corduroy background pattern is an instrumental effect. Naval Research Laboratory photographs.

magnitude of 24.2 moving slowly against the background stars. It was only eight arc-seconds away from the position predicted. At the time, the comet was 1.6 billion kilometers away from the Sun, well beyond the orbit of Saturn. It was the earliest detection of a comet in history — a rare chance for astronomers to observe an incoming comet so far from the Sun.

We know that all comets come from somewhere beyond the frigid reaches of the outer solar system. There a comet is no more than a tiny "asteroid" made of frozen materials we on our warm terrestrial surface think of as gases — methane, ammonia, carbon dioxide, hydrogen cyanide — plus water. In the intense cold, these "gases" are frozen hard as rock.

No one knows precisely where comets formed in the young solar system. The currently accepted scenario goes something like this: somewhat more than 4.6 billion years ago, a gas cloud perhaps a light-year across began to collapse upon itself. As it collapsed, it flattened into a disk. Our Sun formed in the densest place, at the center of the disk, while small particles of metal and rock condensed in the central plane. Farther from the Sun, where it was much colder, ices condensed from the cloud.

As the young Sun contracted, heated, and finally began to shine, its radiation warmed the cloud. Volatile materials (i.e., materials with low melting points such as hydrogen and methane) in the inner regions of the disk — where the planets Mercury, Venus, Earth, and Mars were forming — became gaseous and were blown back into interstellar space. Since the elements which give rise to volatile materials make up the bulk of the Sun, the rocky materials left in the inner solar system were only a small fraction of the mass of the disk.

The outer disk was different. It never grew hot near Jupiter, so the nebula retained volatiles — snow and dust — as its prime constituents. Thus the "gas giants" — Jupiter, Saturn, Uranus, and Neptune — grew enormous as their expanding gravitational pulls swept up icy, dusty matter from the cloud.

What Uranus and Neptune failed to capture escaped into deep space, flung outward by encounters with those giants. This primordial debris now resides in the Oort Cloud, a Sun-centered halo of tiny icy bodies roughly 10,000 times farther from us than Pluto.

The Oort Cloud may extend two light-years from the Sun. The "primordial snowballs" within it are bound so weakly that the infinitesimal gravitational fields of passing stars perturb them, starting them inward on a long fall toward the Sun — or outward, to be lost among the stars.

Most comets that fall toward the Sun probably never get close enough to heat up; they pass undetected outside Pluto's orbit. A few, however, come close enough that the gravity of massive Jupiter alters their orbits ever so slightly, sometimes flinging them outward and sometimes inward — into highly-eccentric elliptical orbits.

Once captured in orbit, the comet will return again and again even if only once every million years. Each time the comet returns, it may encounter one of the giant planets — running the gamut between ejection from the solar system and further shrinkage of its orbit about the Sun.

Roughly 1000 comets have been recorded in history. Of those, 100 are classed as "periodic"; that is, they have made repeated passages near the Sun. But out in the Oort Cloud, the vast reservoir of comets that have never been perturbed into the inner solar system, perhaps 100 billion comets reside. Although this sounds like a lot of material, the combined mass of all the comets in the Oort Cloud probably does not exceed the mass of Earth.

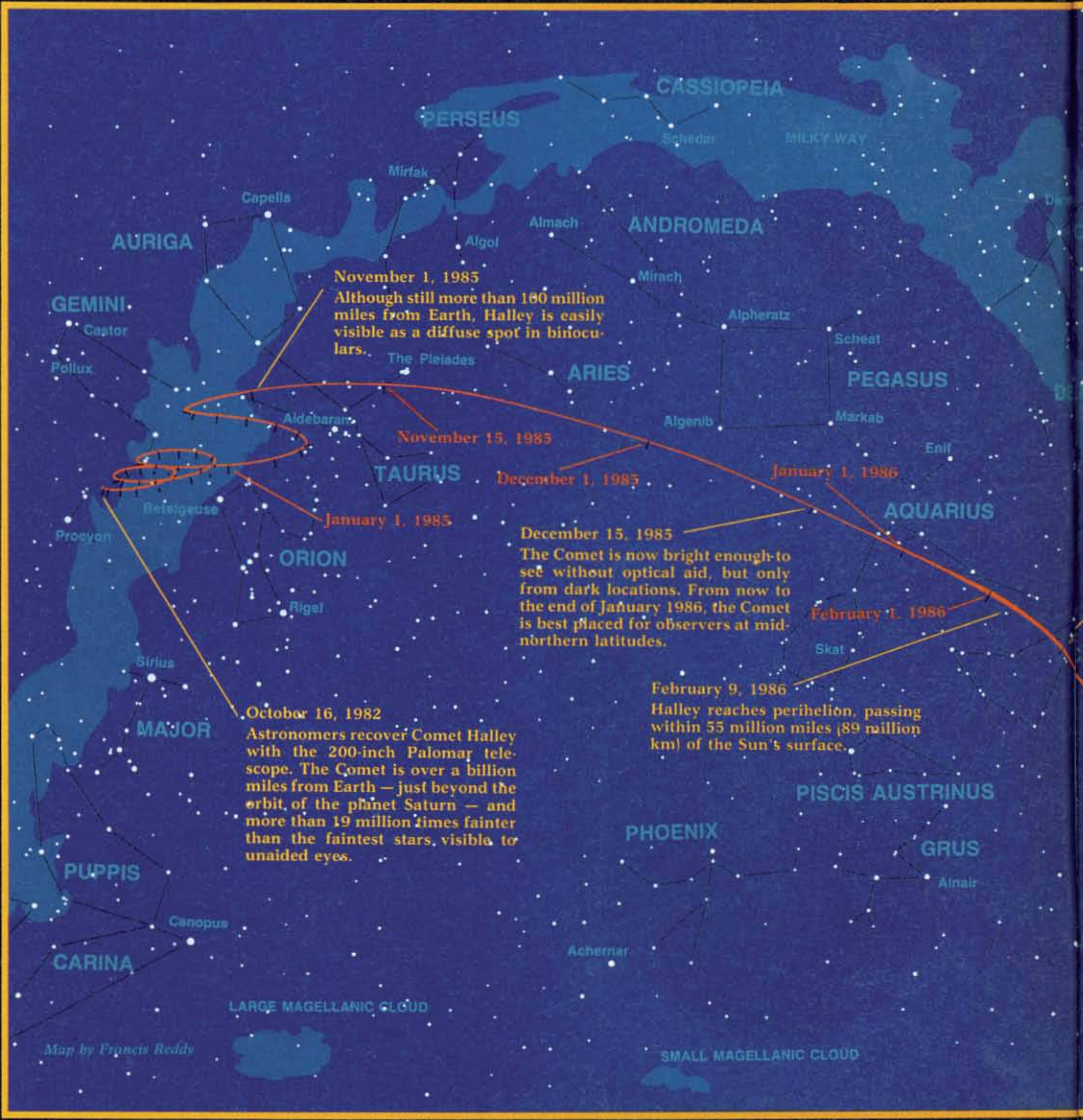
One might think that comets in Earth-crossing orbits could spell trouble for Earth, but the chances of a collision are slim. Even if a comet nucleus did hit Earth, it wouldn't cause major damage. Besides — we are routinely showered with comet debris. Remember that comets formed from primordial ices and dust. As a comet passes close to the Sun, the ices melt or vaporize, then get swept back into space, forming the luminous tail. Without the ice to bind it together, cometary dust escapes, eventually spreading along its entire orbit. If the orbit happens to intersect Earth's orbit, then our planet will encounter comet dust whenever it crosses a comet's orbit.

As our planet plows through the thin stream of tiny dust particles, we see them as quick trails of light — meteors burning up high in Earth's atmosphere. Comet Halley is responsible for two meteor showers: the Eta Aquarid, which is most active around May 4 each year when Earth passes through the densest part of the stream, and the Orionid Shower, which peaks around October 21. Since Halley has been around a while, its debris is distributed evenly throughout its path, so the resulting showers are not very spectacular.

But suppose hundreds — or even thousands — of comets were perturbed into orbits intersecting that of Earth

Less active than Comets West and Halley, Comet Kobayashi-Berger-Milon of 1975 grew a single narrow tail. Although it appears straight in this picture, astronomers observed knots, kinks, and twists moving down the tail. Because these features remained identifiable from one night to the next, astronomers could observe ionized gas in the tail interacting with the solar wind. Photograph by Orien Ernest.

The Return of


CASSIOPEIA
PERSEUS
Schedar
MILKY WAY
Mirfak
Capella
Almach
ANDROMEDA
AURIGA
Algol
Mirach
GEMINI
Castor
Alpheratz
Scheat
Pollux
The Pleiades
ARIES
PEGASUS
Aldebaran
Algenib
Markab
November 15, 1985
Enif
TAURUS
December 1, 1985
January 1, 1986
Betelgeuse
January 1, 1985
AQUARIUS
Procyon
ORION
Rigel
February 1, 1986
Skat
Sirius
MAJOR
PISCIS AUSTRINUS
PHOENIX
GRUS
PUPPIS
Alnair
Canopus
Achernar
CARINA
LARGE MAGELLANIC CLOUD
SMALL MAGELLANIC CLOUD

November 1, 1985
Although still more than 100 million miles from Earth, Halley is easily visible as a diffuse spot in binoculars.

December 15, 1985
The Comet is now bright enough to see without optical aid, but only from dark locations. From now to the end of January 1986, the Comet is best placed for observers at mid-northern latitudes.

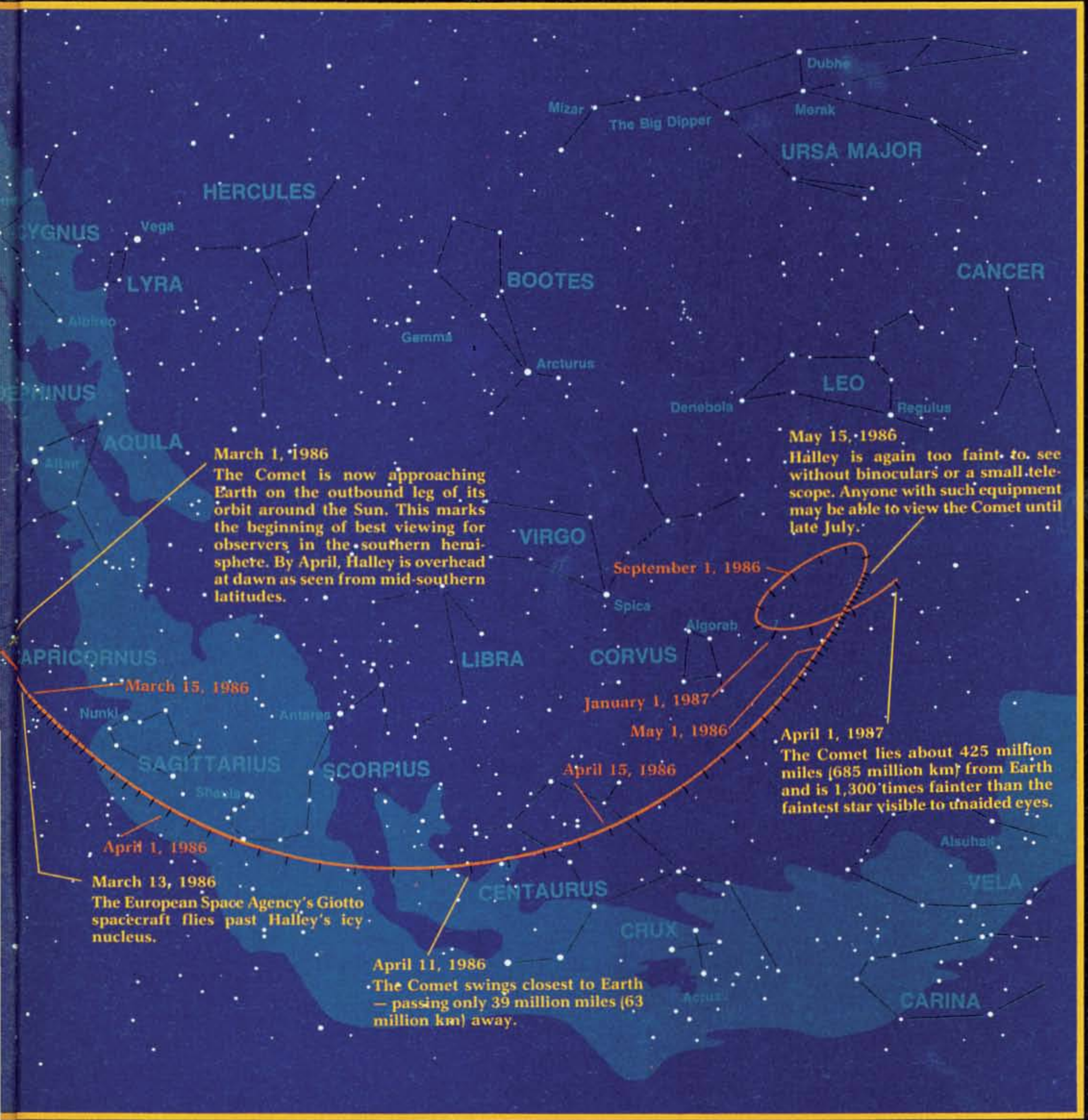
October 16, 1982
Astronomers recover Comet Halley with the 200-inch Palomar telescope. The Comet is over a billion miles from Earth — just beyond the orbit of the planet Saturn — and more than 19 million times fainter than the faintest stars visible to unaided eyes.

February 9, 1986
Halley reaches perihelion, passing within 55 million miles (89 million km) of the Sun's surface.

Map by Francis Reddy

Halley swings across three-quarters of the sky in only seven months after spending years moving only a few degrees. Its motion across the sky reflects not only its own motion around the Sun, but that of the Earth as well. As Earth moves around the Sun, the Comet traces a

Halley's Comet


Dubhe
Mizar
The Big Dipper
Merak
URSA MAJOR
HERCULES
YGNUS
Vega
LYRA
Albireo
BOOTES
CANCER
Gemma
Arcturus
LEO
Denebola
Regulus
ELPHINUS
AQUILA
Altair
VIRGO
Spica
Algorab
CORVUS
APRICORNUS
LIBRA
Nunki
Antares
SAGITTARIUS
SCORPIUS
Shaula
CENTAURUS
CRUX
Acrux
Alsuhail
VELA
CARINA

March 1, 1986
The Comet is now approaching Earth on the outbound leg of its orbit around the Sun. This marks the beginning of best viewing for observers in the southern hemisphere. By April, Halley is overhead at dawn as seen from mid-southern latitudes.

May 15, 1986
Halley is again too faint to see without binoculars or a small telescope. Anyone with such equipment may be able to view the Comet until late July.

September 1, 1986

March 15, 1986

January 1, 1987

May 1, 1986

April 1, 1987
The Comet lies about 425 million miles (685 million km) from Earth and is 1,300 times fainter than the faintest star visible to unaided eyes.

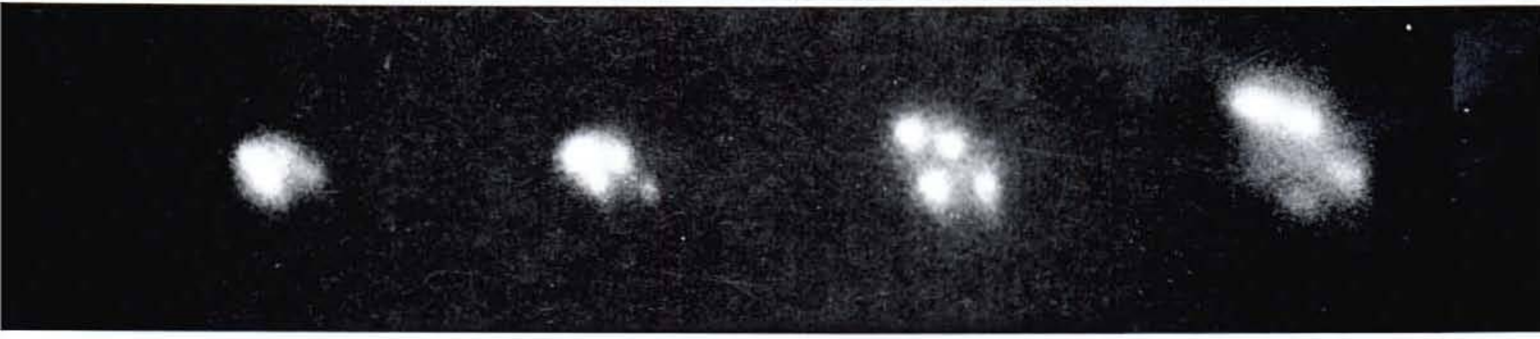
April 15, 1986

April 1, 1986

March 13, 1986
The European Space Agency's Giotto spacecraft flies past Halley's icy nucleus.

April 11, 1986
The Comet swings closest to Earth — passing only 39 million miles (63 million km) away.

loop because Halley is close to us relative to the very distant stars. Plunging through the inner solar system, Halley makes its closest approach to Earth on April 11, 1986 — two months after it swings past the Sun. Halley's Comet won't be visible again until the summer of 2061.



Over a two-week period in February and March 1976, the nucleus of Comet West split into four fragments. Shown greatly enlarged in these photos, all four components remained embedded in a single coma. Courtesy New Mexico State University Observatory.

and many made direct hits. What then? Although the total matter from the comets might not amount to much, it could kick up material from Earth's land and oceans into the atmosphere, increasing its opacity and reducing the amount of sunlight reaching the ground. This, in turn, would lower Earth's temperature and perhaps even trigger an ice age. Thankfully, we do not, at present, have any reason to expect large numbers of comets to hit Earth.

Since we are not particularly worried about being hit by a comet, let's consider what, exactly, a comet is. Harvard astronomer Fred Whipple proposed the "dirty snowball" model in the 1950s, a concept which still appears fundamentally correct. The cometary body itself, called the nucleus, is seldom more than 10 kilometers in diameter; it consists of a core of ices mixed with dust, surfaced by a crust of dark dust. When a comet is far from the Sun, that's all there is to it.

However, when we see a comet in the inner solar system, it is no longer a frozen icy body. Surrounding the nucleus is the coma (from the Latin word meaning "hairy"), an envelope of gas several thousand kilometers across. Through a telescope, the coma appears soft and fuzzy, denser near the nucleus and fading toward the edges. The density of the gases in a comet coma amounts to only one-millionth of the pressure at terrestrial sea level. Often the coma shows jets and streams arcing away from the nucleus — an indication that the nucleus is not a quiet place.

Comet tails point away from the Sun. The outflowing solar wind — a continuous stream of fast-moving protons and electrons — strips away the gas of the coma and carries it downwind into space forming the comet's tenuous tail. Although the tail may extend many millions of kilometers, it is more tenuous than the coma — about 1/10-trillionth as dense as Earth's atmosphere.

Comet tails become visible as the comet approaches within three astronomical units (AUs) of the Sun: the gases in the tail begin to glow under intense solar ultraviolet light; as the molecules absorb energy, they radiate light at optical wavelengths. The gases also disassociate, breaking into smaller molecules and fragments of molecules.

In the process of fluorescing and dissociating, the atoms and molecules in the tail and coma tell us much about themselves. By measuring the wavelengths emitted from the comet with a spectroscope attached to their telescope, astronomers can record the characteristic patterns of familiar terrestrial materials in the exotic environment of the comet. Comets consist of simple molecules formed from the universe's most common elements: hydrogen, oxygen, nitrogen, carbon, sulfur, plus a few heavier elements. Astronomers have deduced that these molecules and molecule fragments must come from "parent" inorganic ices — ammonia (NH_3), NH, NH_2, oxygen, hydroxyl (OH), and water (H_2O) — and organic ices — carbon (C_2, C_3), CH, carbon monoxide (CO), cyanogen ($(CN)_2$), carbon sulfide (CS), methane (CH_4, HCN, CH_3, CH), and carbon dioxide (CO_2). Sodium, calcium, chromium, cobalt, manganese, iron, nickel, copper, vanadium, and silicon have also been observed in comets. The molecules observed in the tails of comets are similar to the simple molecules found in their comas.

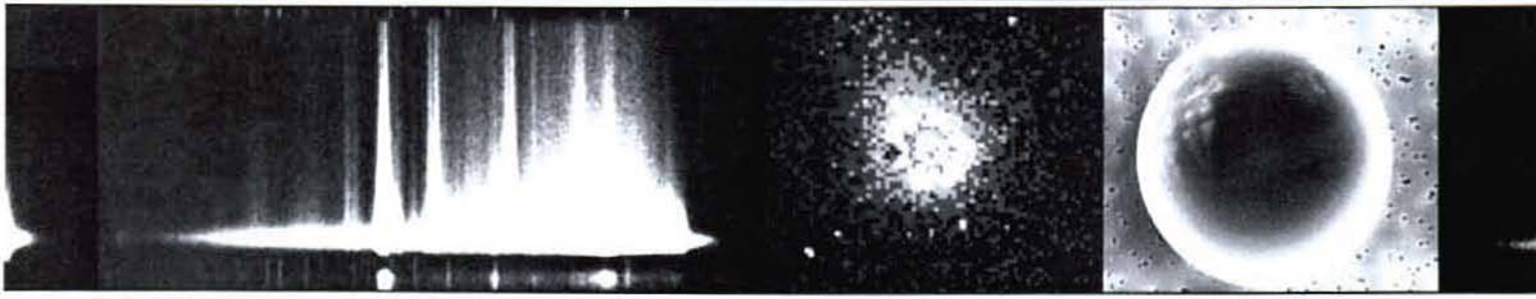
Because the coma and tail gases boil off the nucleus, the comet loses some of itself each time its orbit carries it near the Sun. For a typical comet, the loss amounts to some 100 billion kilograms; in comparison, a terrestrial rainstorm that drops one centimeter of rain on a region 100 kilometers square would drop the same mass — so 100 billion kilograms is really not a large amount. Comet Halley has a mass of about 10 million billion kilograms, roughly one 1/100-millionth the mass of Earth. Thus Halley can make 100,000 orbits before losing all of its material.

Most comets have not one, but two tails. One is a gas tail (also called the plasma or ion tail) and the other is a dust tail. The gas tail is oriented by the solar wind (charged particles coming from the Sun) much as a flag is blown by terrestrial winds. The outflow of solar particles strips electrons from the gases in a comet coma, then the solar magnetic field carries the charged particles or plasma away from the comet. The gas tail is long and straight, and appears bluish in color due to the strong blue and violet emission.

The dust tail is made of solids — dust — from the nucleus of the comet. Dust is swept back from the comet along with the gases in the tail, but unlike ionized gas, the solar magnetic field has no hold on them. Gravity and the comet's orbital motion gently swing the dust particles into a solar orbit, spreading them into the graceful curve we normally associate with comet tails. In photographs, the dust tail appears broad, curved, and yellowish in color. Dust from the tail eventually spreads along the comet's orbit to become a cometary meteor stream.

Scientists have worked long and hard to understand

Comet West's dust tail, yellow because it shines with sunlight slightly reddened by reflection from finely-divided particles, arcs gently along the comet's orbit. The gas tail glows blue because molecules of the gases present in the coma and tail absorb solar ultraviolet then reradiate the energy in the blue part of the spectrum. Photograph by Robert Provin.



Left: The spectrum of Comet Mrkos shows emissions of cyanogen, CN, ionized carbon monoxide, CO^+, and the C_2 carbon molecule. Lick Observatory photograph. Center: Comet Austin, observed by the IUE satellite, shows an extensive halo of hydrogen gas. NASA photo. Right: This tiny ball, enlarged 3000 times, is a bit of comet dust captured by a high-flying aircraft.

and predict the shape and flow of comet tails, but the task is complicated by the recently-discovered fact that comet nuclei rotate. The nucleus of Comet Halley, for example, has a rotational period of about 24 hours, while that of Comet Encke is six hours. The direction in which the nucleus rotates as well as its period and orientation of the rotational axis all affect the dust tail's shape.

As the rotating nucleus loses matter, centrifugal and tidal forces may become strong enough to crack or split the nucleus, especially since ice is weak compared to the rocky materials of asteroids and the inner planets. Such a break-up happened to Comet West in 1976; its passage near the Sun split the nucleus into four fragments, which then slowly drifted apart.

Although they are among the smallest bodies in the solar system, comets may preserve the materials from which the solar system formed — and that makes these "lightweights" very important. As a result, astronomers all over the world have planned a vast array of coordinated scientific investigations of Comet Halley during its 1986 apparition: the European Space Agency will launch a vehicle named Giotto to fly within 1000 kilometers of the comet's nucleus; the U.S.S.R. will launch two Vega satellites, which are scheduled to rendezvous within 10,000 kilometers of the nucleus; and Japan has a vehicle, called Planet A, slated for an encounter at 100,000 kilometers' distance.

The U.S. does not plan to launch a mission to Halley, but nonetheless has many related experiments planned. The International Comet Explorer, an Earth-orbiting satellite re-directed to comet Giacobini-Zinner, will direct its instruments toward Halley from a range of 30 million kilometers. If all goes well, the Space Shuttle will be launched when the comet is some 70 million kilometers distant. NASA's Marshall Space Flight Center is in charge of equipment being designed for this flight. On-board spectrographs, polarimeters, and wide-field cameras will play a role in collecting data to help determine the composition of Comet Halley and the nature of its interaction with the solar wind during this leg of its orbit.

Another important source of data will be the International Halley Watch, a cooperative effort linking both professional and amateur astronomers around the globe. The observing time will be greatest among amateur observers and valuable information about the comet's variability should be obtained by them.

Comet Halley will reach perihelion on February 9, 1986. Its closest approaches to Earth will occur November 27, 1985 during its inbound journey, and April 11, 1986 on its way out from the Sun. The November passage will occur when the comet is 0.62 AU distant (about 100,000,000 km); in April it will be at 0.42 AU (some 60,000,000 km) from Earth.

Halley will surely be most spectacular during its second close approach, perhaps brightening to second-magnitude. Unfortunately for northern viewers, the encounter will best be seen from the southern hemisphere. For the northern hemisphere, November offers better viewing opportunities. On November 12, for example, the New Moon will provide a dark sky background for observing Halley. On the night of November 16 and 17, while the Moon is still young, Halley will move just south of the brilliant open star cluster, the Pleiades. Then it will be around seventh magnitude — a nice object in binoculars or a small telescope. By January, Halley will have brightened to fourth or fifth magnitude and be visible in the evening sky, roughly 30° high, for most of the United States. In late February, March, and early April, northern viewers will see it low in the morning sky as it moves southward. The tail will probably be longest in late March, but the comet will be low on the horizon during this part of its journey.

How bright a comet will be is always uncertain, since it depends on its size, chemical composition, rotation, and the amount of dust the comet ejects. Brightness also depends on the distance between the comet and the Sun, and between the comet and Earth. In 1974, Comet Kohoutek was a major viewing disappointment when it failed to become as bright as it might have. In 1976, brilliant Comet West went virtually unnoticed by the general public.

Whatever Comet Halley's brightness and appearance this time around, it is certain to stimulate the millions who view it — as it has for at the past 22 centuries. This time, perhaps, its appearance will enrich our understanding of the early solar system and the evolution of life on Earth, and serve as a reminder of the profound mystery of our origins.

At its brightest in the fall of 1911, Comet Brooks sported a 30° long tail. This closeup of the coma and inner tail reveals shells shed by the nucleus blowing back into the tail. The nucleus is lost in the center of the overexposed coma. Brooks is a periodic comet that will return a little over 2000 years from now. Lick Observatory photograph.

Debra Elmegreen is a visiting scientist at IBM's Watson Research Center. Her research interests include not only the comets, but also the structure of spiral galaxies in the infrared as well as how star formation occurs in galaxies.

Comets, "Death Stars," and Extinctions
The Rise and Fall of a Scientific Theory

by
Ray Grasshoff

They dominated life on Earth for some 160 million years, yet disappeared — in cosmic terms — instantaneously. Today, only scattered fossilized bones and eggs mark their passing. Researchers have long been baffled by the speed with which the Cretaceous-Tertiary event killed the dinosaurs 65 million years ago, but the last decade has seen numerous speculations spring from the imaginations of scientists. Even if their ideas have not really hit the mark, they have convinced many paleontologists and biologists that the sciences of life may be curiously dependent on astronomy — and established that whatever connection may exist between the history of life on Earth and astronomical events should be explored more fully.

What happened to the dinosaurs? They survived for well over 100 million years, then suddenly disappeared from the fossil record. Early hypotheses concerning their demise concentrated on biological events. Some scientists suspected, for example, that as mammals evolved, they ate dinosaur eggs faster than the eggs could hatch. Others speculated that slightly warmer temperatures affected food sources or dinosaur reproductive systems. Despite all the talk of extinction, some biologists claimed — with more than a little evidence to support their assertion — that the dinosaurs' demise was a gradual event requiring no elaborately-concocted explanations.

In 1980, a team of scientists led by Luis Alvarez of the University of California at Berkeley suggested mass extinctions may have resulted from an "extraterrestrial" event. They believed an asteroid — like one of the thousands of small rocky bodies which orbit between Mars and Jupiter — struck our planet. Such an impact, they suggested, would have raised a huge dust cloud and thrown debris high into the atmosphere. As the dust spread over the planet, it would effectively keep sunlight from reaching the surface and cause major changes — even extinctions — in the Earth's plant and animal life. Even species not directly affected by the darkness could have been indirectly affected if their sources of food died out.

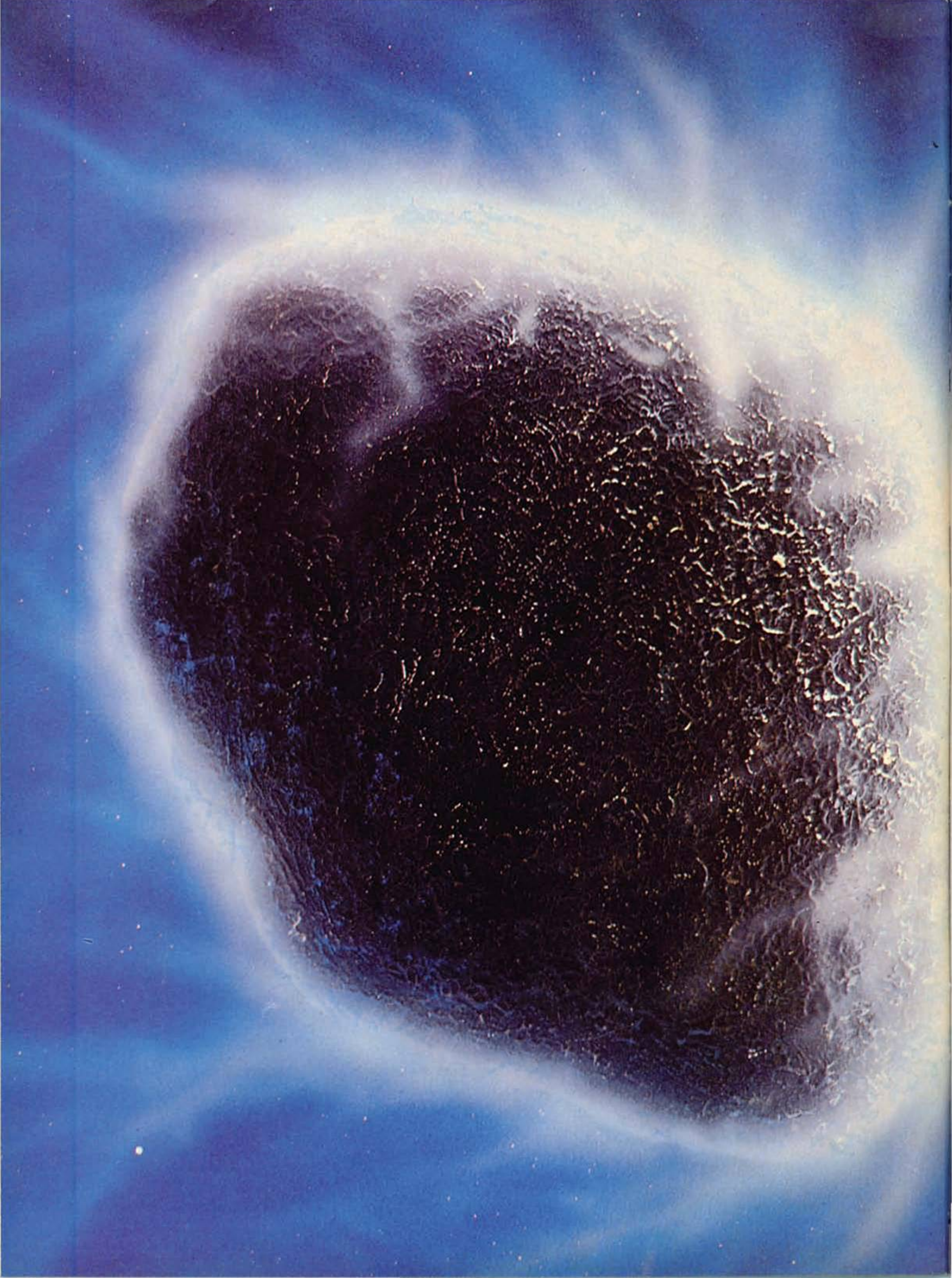
Alvarez's group acquired considerable supporting evidence from studies of the abundance of the element iridium found in terrestrial rocks. Iridium is very rare in the Earth's crust, but is more abundant in meteors and asteroids. Alvarez reported unusually high concentrations of iridium in sedimentary rocks deposited approximately 65 million years ago — the time dinosaurs began to disappear. Their studies suggested that a large asteroid or similar body struck Earth and devastated its inhabitants. As debris from the impact eventually settled out of the atmosphere, it left a telltale signature of iridium-rich dust buried in the rocks of our planet.

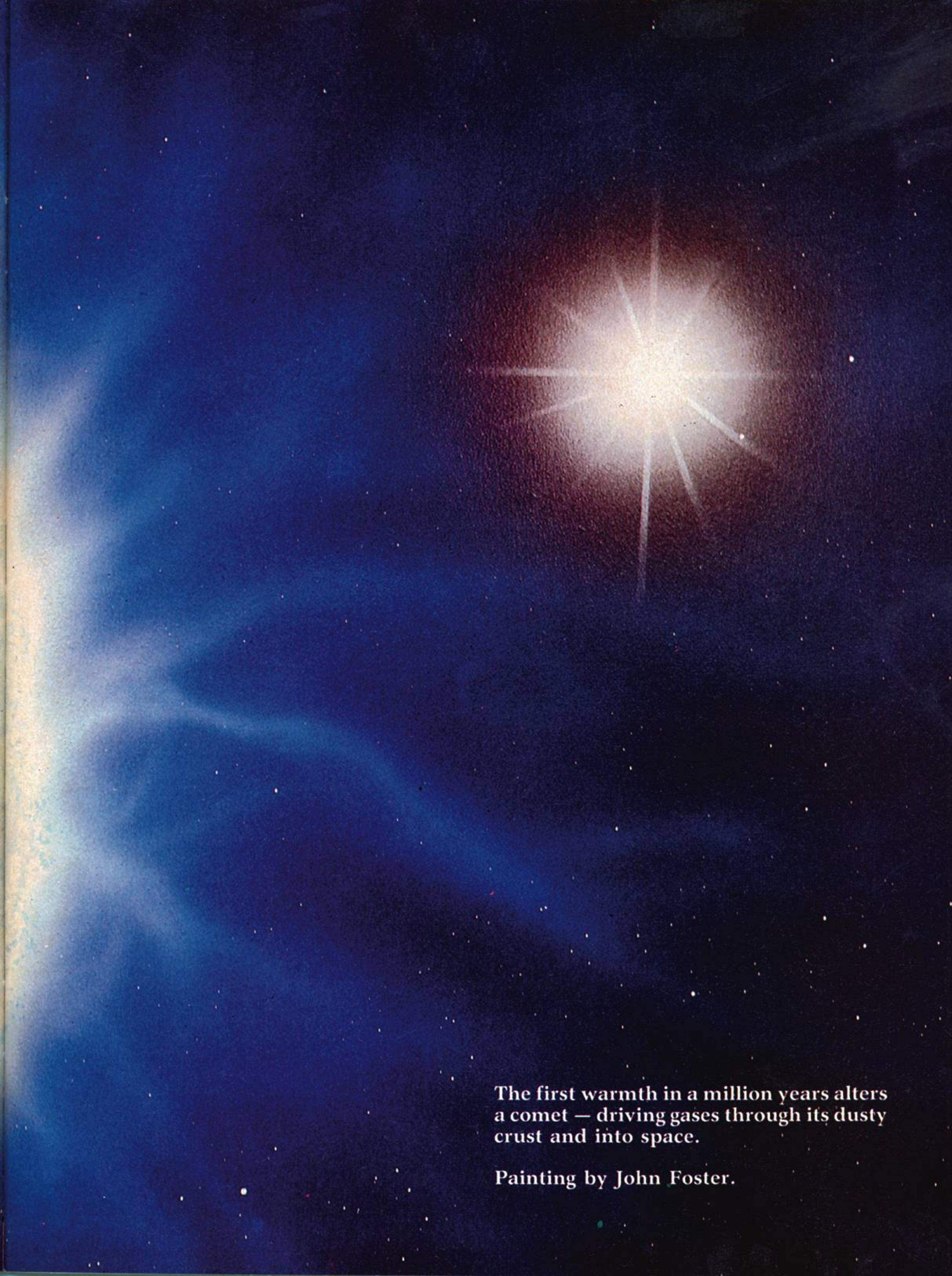
Alvarez and his group's ideas have turned out to be the seed for a larger, more comprehensive scenario. Scientists have not only found other extinctions of Earth's plant and animal life contemporaneous with the extinction of dinosaurs, but also mass extinctions at other times. David Raup and John Sepkoski, both of the University of Chicago, conducted an extensive study of more than 3,500 families of marine animal life. In August 1984, they published an analysis of their data that showed mass extinctions of life on Earth occurred about every 26 million years. Another scientist offered independent support for their findings, showing the last extinction occurred only 11 million years ago and had been preceded by extinctions 37 and 66 million years before that. Other studies show extinction periodicities of 32 million years, with greater extinctions every 225 to 275 million years.

There was no obvious terrestrial cause for such a cycle (though there are many well-known cycles of shorter duration), so scientists looked to the heavens. Only one similar cycle has come to light. In its orbit around the Galaxy, the Sun takes roughly 250 million years to complete one full rotation. Mathematical models of the orbit show that we pass through the galactic plane — a densely packed region — about once every 33 million years. Given the precision to which such astronomical data are known, the 26-million-year extinction cycle was sufficiently near 33 million years to lead other scientists to propose the cause of the extinctions is the passage of the Sun and solar system through the galactic plane.

Michael Rampino and Richard Strothers of NASA's Goddard Institute for Space Studies then took the proposal one step further. They suggested that passage through the dusty crowded plane of the Galaxy would almost certainly result in a collision with clouds of cold gas, dust, and debris. Such a collision would disturb the vast Oort Cloud, the halo of comets surrounding the solar system. If a small fraction of these comets were perturbed and fell in toward the Sun, the number of comets passing through the inner solar system would be far greater than normal. Although comets now seldom collide with Earth, this would increase the likelihood of an impact. According to Rampino and

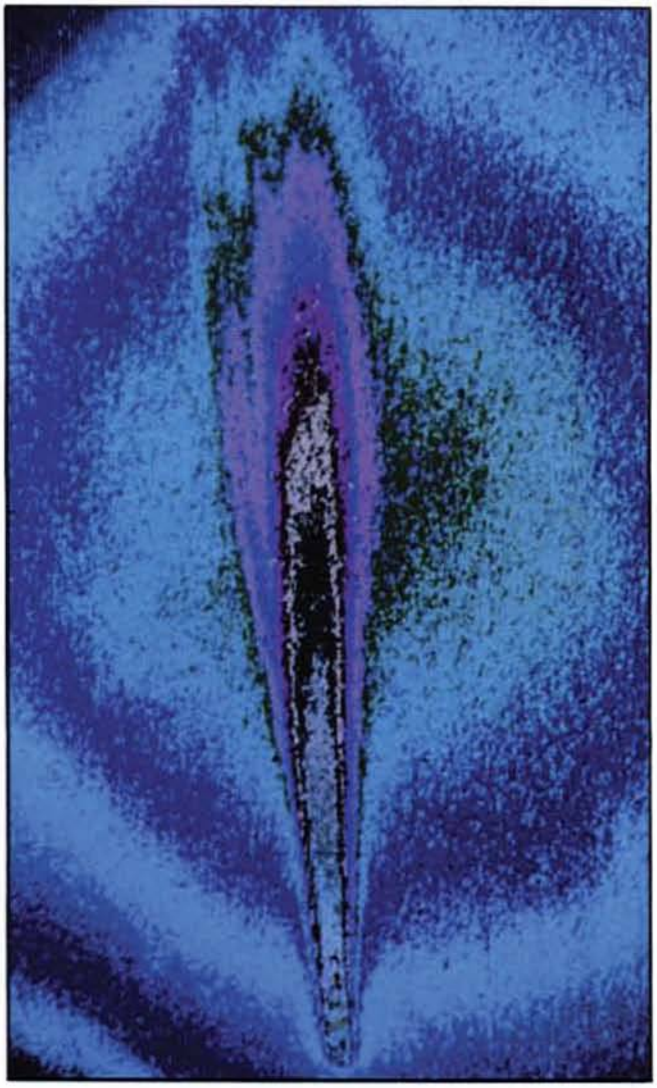
Was it a comet that slammed into the bedrock of Quebec 212 million years ago? Today, Lake Manicouagan's waters highlight heavily eroded rocks inside the ancient crater's ruined rim. Manicouagan is one of the oldest positively identified impact craters on Earth. Landsat photograph courtesy of NASA.





The first warmth in a million years alters a comet — driving gases through its dusty crust and into space.

Painting by John Foster.



Comet Halley's orbit crosses Earth's, so twice each year dust lost from the comet impacts our atmosphere as meteors. If Halley itself impacted, the damage, on a global scale, would be slight. But suppose that hundreds, or even thousands, of comets impacted our planet — what then? Photograph © AURA, Inc.

Strothers, "comet showers" would occur whenever the solar system passed through a galactic dust cloud — and the chances of that happening are greatest when the solar system crosses the galactic plane.

Rampino and Strothers then searched the Earth's surface for evidence of comet collisions. What they found was striking: estimated ages of impact craters on Earth clump at intervals of 30 to 31 million years — close enough to a 26 million year cycle to qualify as a match for the biological extinction cycle. When their analysis was confirmed by another group, the notion that astronomical catastrophes caused periodic extinctions of terrestrial life gained credibility.

While searching for multimillion-year astronomical cycles, other scientists seized on another phenomenon. Most stars in our Galaxy are part of multiple star systems — two or more stars orbiting around a common center of gravity. Could the Sun be part of such a system without our knowing it? If so, the companion star must not be very massive or bright. But if it *were* there, could such a companion star affect the Oort Cloud, sending hordes of comets into the inner solar system every 26 to 33 million years?

Such a star has never been observed, but on the off-chance that it might exist, astronomers have begun searching data sent to Earth last year by the IRAS infrared satellite. (See "IRAS and the Infrared Universe," March 1984.) The likely candidate would be a cool faint star, invisible at optical wavelengths, but bright enough in the infrared for IRAS to detect. If such a star — now dubbed "Nemesis" or "The Death Star" — exists but is too small for direct observation, the theory cannot be readily proven or disproven.

To have the desired effects on the Oort Cloud, Nemesis would have to be a small star with 1 to 10 percent of the Sun's mass and a highly eccentric orbit with a period of 30 million years. The orbit would take Nemesis within perhaps 10,000 AUs of the Sun, then swing it some 200,000 AUs away — or nearly a light-year from the Sun. Each time Nemesis passed through the Oort Cloud, it would send thousands of comets raining down on the inner solar system, some striking Earth.

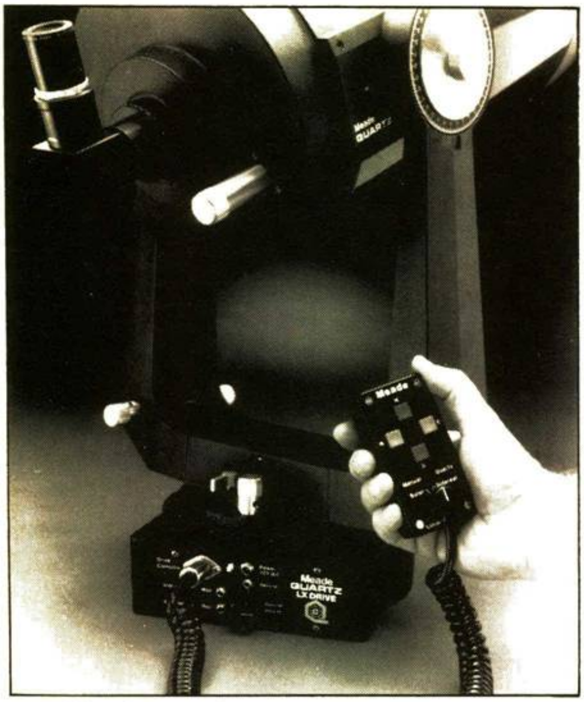
Though wonderfully melodramatic, Nemesis is not entirely healthy as a scientific theory. It invokes a star, which has never been observed, to perturb the Oort Cloud — itself a theoretical construct (though considerably sounder than the Nemesis construct) created to explain the number of new in-falling comets — so that large numbers of comets will periodically collide with Earth to cause as yet not-well-understood climate effects to do in the dinosaurs. Considering that extinctions of species are not firmly established and *could* be explained by purely terrestrial means, Nemesis seems a bit farfetched, or at very least, an unnecessary hypothesis.

Nonetheless, the Nemesis proposal was promptly explored — and several discoveries made. Nemesis would travel so far from the Sun that its orbit would be severely perturbed by passing stars and the general gravitational field of our Galaxy. Even if it remained gravitationally-bound to the Sun and didn't spin off on its own, its period would vary considerably from orbit to orbit. Few double stars with separations greater than half a light-year have been observed, so this figure may represent a practical upper limit for double star orbits and tends to confirm the models. In addition, the orbital stability of Nemesis depends strongly on its inclination with respect to the galactic plane; a Nemesis in a highly-inclined orbit would soon be lost.

At present, the Nemesis proposal stands partially discredited not only because of the relative plausibility of the galactic plane/dust cloud hypothesis, but also because even if Nemesis *had* once orbited our Sun, it is likely to have been lost long ago. Even the galactic plane hypothesis suffers from difficulties, not the least being that extinctions purportedly occurred when the Sun was farthest from — rather than nearest to — the galactic plane.

But astronomy has not suffered for it. The ideas proposed, the discussions that followed, and increased awareness of possible links between astrophysics, paleontology, marine biology, and geology only serve to broaden and enrich the history of life on our planet Earth — and take us a little closer to understanding what really *did* happen to the dinosaurs.

Ray Grasshoff is a freelance science writer and frequent contributor to AstroNews.



The best just got better.

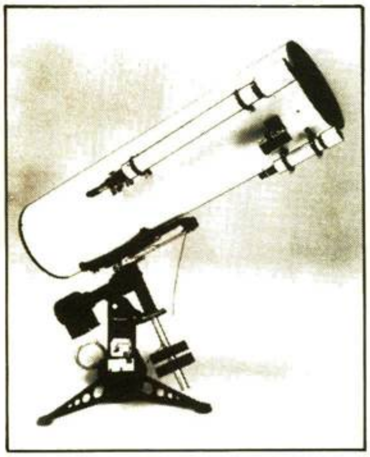
Save $1000^{00} on the new Meade quartz-drive 2080/LX3!

Elsewhere in this magazine, you'll find a Meade advertisement describing the revolutionary Meade 2080/LX3.

It will tell you about the built-in quartz drive, the most accurate available for any commercially-made telescope, one that operates from either house current or your car battery with no adapter needed. You'll learn about the new Multi-Coated/Silvered Optics Group that gives the 8" 2080/LX3 the effective light grasp of a 9" telescope. You'll learn about the multi-coated diagonal with better than 98% reflectivity (the highest of any production diagonal); the compass on the wedge that allows polar alignment even when trees or buildings obscure the northern skies; about the standard equipment illuminated polar axis 8 x 50mm finder and piggyback camera bracket; about the *lifetime warranty*. You'll learn why the Meade 2080/LX3 is the best 8" Schmidt-Cassegrain telescope ever made.

The only thing that could make it even better is the $1000 savings you'll find at Ad-Libs Astronomics. Complete with wedge, tripod, and all standard accessories — plus the optional Multi-Coated/Silvered Optics Group — the LX3 lists for $2950. Our price? Only $1950, freight paid! You save $1000 on the best 8" telescope ever!

Save 25% on Meade deep space scopes — 30% on Schmidt-Cassegrains!



At Ad-Libs Astronomics, we'll save you 25% off the list price of any Meade reflector telescope — from the incredible DS-10 and DS-16 Deep Space telescopes, to the best-buy Models 628, 645, and 826 Deluxe Series, to the observatory-grade Research Series.

We'll save you 30% off the list price of the best-selling 4" and 8" Meade Schmidt-Cassegrain telescopes, too — the 2044, 2080, and 2080/LX2.

And we'll save you 10% to 25% on Meade photo and visual accessories for all these scopes, as well!

Meade announced a price increase effective February, but details were not available when this ad was written (12/84). All prices and discounts are therefore good though 3/31/85 only, and will be based on the Meade list prices in effect when your order is received.

Authorized
Meade
Dealer

Similar big savings on other brands, too!

Not only will we save you money on *all* Meade telescopes and accessories, but we'll save you money on every other brand we carry, as well!

Celestron, Questar, Bausch & Lomb, TeleVue, Edmund, Lumicon, Unitron, Coulter, University Optics — we'll save you money on all of them!

Send a stamped, self-addressed envelope for our *free* discount price list showing your savings on the more than 70 telescopes and 500 accessories we carry — or send $1 for our complete catalog that takes the guesswork out of picking the right telescope, and saves you money, too!

ad-libs astronomics Our 6th year of saving you money!

2401 Tee Circle, Suite 106, Norman, Oklahoma 73069 *(405) 364-0858*

MasterCard and Visa. Freight additional on credit card orders. North American sales only.

ASTRONOMY
Forum

Planetary Astronomers Meet in Hawaii

This year, American planetary astronomers met in Kailua on the western shore of the big island Hawaii. They were there not only because many astronomers call Hawaii their home but also because much of the world's planetary astronomy is now carried out atop the cinder cones of Mauna Kea, the older of the big island's two giant shield volcanoes. Isolated by its altitude from the water vapor and the warm ocean winds, Mauna Kea is dry, cold, nearly always clear, and favored by some of the best astronomical seeing on the planet.

On a more mundane level, the Division of Planetary Sciences of the American Astronomical Society (DPS) met in Hawaii because it was Hawaii's turn to host the meeting this year. Thus, I found myself packing clothes, tape recorder, camera and computer for the trip.

The meeting began with registration, each participant receiving a flower lei and kiss — the traditional Hawaiian welcome — from one of the astronomy department secretaries. Promptly at 8:30 the next morning, the first scientific sessions began. With some regrets for what I'd be missing in Session 2, I opted for Session 1 — a series of papers on comets, and in particular, on Comet P/Halley.

Mike Belton of Kitt Peak, a small man who projects a great deal of energy, delivered the first paper on spectra of Halley taken with the 4-meter Mayall telescope while Halley was still very distant from the Sun. His spectrum, taken in February 1984, was a "noisy" line without any obvious trend. Halley was 22nd magnitude at the time, so the signal-to-noise ratio of the curve lay below unity, normally considered the lower limit of detection. "As you can see, it is slightly smooth," he noted.

Belton stressed the importance of getting more observations. "Djogorski and Spinrad have already detected activity in the coma, so our spectra may be unique as spectra of the coma" he said, noting that the comet is "definitely turned on" and showing well over a one-magnitude variation in three hours. "The message I'd like to convey is we don't have much time before Halley becomes a normal comet. We need observations [of the nucleus] quickly — before Christmas."

The next speaker was Zdenek Sekanina, a shy, intense scientist who tended to mumble. "I think it's clear we are on thin ice with Comet Halley," he said. The comet has so far stayed constant in absolute magnitude, and although there have been outbursts, there has not been any global activity. Looking at the light curve with its "sparsely populated sampling" can give "as many peaks as you want" — but there is a series of peaks with periods that are multiples of the solar rotation rate. These, he added, "reflect outbursts of charged dust, and are a possible effect of solar wind on the comet nucleus."

Based on the brightness measurements, Sekanina concluded the radius of the comet nucleus lies between three and five kilometers, depending on the reflectivity assumed for the nucleus. Once cometary activity begins and a coma forms, it will become impossible to determine the brightness of the "bare" nucleus.

There were more papers that morning. Mike A'Hearn, for example, discussed a discrepancy between theoretical expectations and observation, and Susan Wyckoff pressed the importance of carbon dioxide ice in comets. Her concluding remark, "Comets with high CO_2-to-water ratios are comets that have fragmented," triggered considerable give-and-take from the assembled cometary scientists before break time arrived.

After coffee, Tom McCord called the DPS meeting officially to order. David Morrison, Vice Chancellor of the University of Hawaii for Research and Graduate Education, welcomed us on behalf of the University. He then introduced the Mayor of Hawaii County, Magumi Kon, who assured us that "Hawaii is a natural laboratory, with volcanoes, ocean, clean dark skies, and distance from other land masses."

Magumi continued, "I certainly would like to welcome all of you to the Kona-Kalila coast, and hope that some of you came a few days early for the Triathlon, too. Now I know that you're not astronomers, but planetary scientists (I'm glad Tom told me this), and I'm sure that some of you have used or will be using the world-class telescopes on Mauna Kea mountain."

The next scheduled speaker was Hawaii Senator Spark Matsunaga, whom McCord described as "strongly supporting research efforts not only here, in Hawaii, but as part of our national program. That's the good news," continued McCord; "the bad news is the Senator is not here. So, representing the Senator is Harvey Meyerson of the Senator's staff."

Meyerson began with some good news of his own: "Those of you who have followed it will know that certain legislation has been passed out of committee, and Senator Matsunaga hopes to bring this up today or tomorrow on the floor. On the Senator's behalf, I'd like to thank you who, by your testimony, have helped with this bill." Meyerson then read the text of Senator Matsunaga's talk, a discussion of the relationship between science, politics, the military establishment, and our society.

"When science plays a role of no

Odyssey

CHALLENGE A Young Imagination with FACT — not FICTION with a FREE issue of ODYSSEY

Have you ever wondered if there was a space and astronomy magazine that could satisfy your child's curiosity about the wonders of the universe in a factual, challenging, yet entertaining way — a magazine that YOU could have enjoyed before you moved on to ASTRONOMY?

Well, there is — ODYSSEY, the magazine of astronomy and outer space for young people 8 to 14 years old.

ODYSSEY is published by the same people who bring you ASTRONOMY, so you know quality is important. ODYSSEY features articles on speculative science, the foundations and frontiers of astronomy, and basic "hands on" observation. It challenges children to exchange ideas about space colonization and life on other planets. Then, just a turn of the page away, it teaches them how to locate Saturn, Jupiter, Orion and Gemini — all the visible planets and constellations in the night sky. ODYSSEY also features science related puzzles, games and projects to help develop your child's creative talents.

Take advantage of the Free Issue offer below and bring your child 12 issues of ODYSSEY at our special introductory price. It could do more than give your child his or her own space and astronomy magazine . . . it could give you a partner in exploring the beauty and wonder of the heavens.

ODYSSEY . . . the magazine that should have been around when you were a kid.

FREE ISSUE CERTIFICATE

YES Please send my special child a free issue of ODYSSEY. We'll look it over and if we like it, I'll return payment of $14.88 when you bill me and recive 11 additional issues. If not, I'll write "cancel" on the invoice, return it to you, and keep the free issue at no cost, commitment or obligation.

Send a FREE copy of ODYSSEY to:

Child's Name ______________________

Address ______________________

City __________ State ______ Zip ______

Send Invoice to:

My Name ______________________

Address ______________________

City __________ State ______ Zip ______

ODYSSEY, P.O. Box 92788, Milwaukee, WI 53202

Send no money, just mail this certificate or a photocopy. For convenience, use the ASTRONOMY envelope bound into this magazine.

Subscriptions to other countries, add $4.00 per year. Please remit in U.S. currency. Allow 4-6 weeks for delivery.

6235

importance, it is free do what it wants," he began, but we must now keep in mind "the increasing dependence of the military on civilian technological and scientific advances. Central to America's success is open and free competition — compare this to the unfolding processes of restrictions. However, it is inevitable that the government will feel constrained to tighten its hold on what it deems militarily important."

He warned that scientists must maintain control of the direction of science. "This may seem far removed from your current interests, [but] if you don't do it yourself, someone else will do it for you — with far less satisfactory consequences." He reminded the scientists of moves already made by the Pentagon to restrict the flow of scientific information.

"In the space age, internationalism is not only good business, it is a necessity." To promote this end, Matsunaga has proposed an International Mars Program, "as an alternative to the Star Wars Program, under what I call aggressive cooperation." Making the Soviets work with us in space, he said, "will tend to open Soviet society and prevent the closing of American society," hinting that increasing government control of science increases the danger of America becoming a mirror image of Soviet society.

"At a certain point, anything other than international cooperation in the exploration of our universe from this tiny planet is impossible. One thing I have learned in a lifetime in politics is that timing is everything. For the good of your profession, and the good of all of us, I hope you will aid in steering us to this end."

The audience reacted strongly, although it was hard to place the reaction. Many of them clearly agreed, but others wanted to stay in their labs. Some thought it wouldn't work. Meyerson replied that it didn't matter, "the current Administration in Washington will not accept it either. The idea is to get people talking, taking the first small steps, and building support for it."

Forced to choose between afternoon sessions on Jupiter and Saturn or more comets, I chose the giant planets. The first paper dealt with the detection of the hydrogen dimer in Jupiter's atmosphere. A dimer, I found out, is two hydrogen molecules loosely attached to each other. The speaker was Dr. Samuelson of NASA/GSFC, who compared theoretical and observed spectra of the planet and concluded, "we have made a positive identification of the dimer." Chris McKay discussed the production of organic molecules by lightning in Jupiter's atmosphere. "We have simulated lightning in a somewhat different way than previous investigators," he said. "Our chamber enables us to do single sparks of very high energy, rather than the low continuous currents of Tesla coils." The goal of his work is modeling the molecular species produced and then testing those models in the lab. In the question session that followed, Carl Sagan asked why they'd used a five percent hydrogen mixture when the actual percentage of hydrogen is about 0.2 percent. McKay didn't have much of an answer, though both agreed the amount of hydrogen probably wouldn't make much difference.

"There's pretty good evidence that the aurora is caused by heavy ions precipitating from the Io torus into the auroral zone," began Tom Skinner, flipping one viewgraph after another onto the overhead projector. "In both cases, at the north and south poles, we see this unusual longitudinal anomaly." Windmilling his arms to illustrate the paths of particles in the jovian magnetic field, he concluded, "We feel the IUE results challenge current models of the jovian magnetic field. They predict we should be seeing aurora all the way around."

Jupiter can maintain a microbial biosphere comparable to a terrestrial aquatic environment.

Each speaker was, of course, running against the clock, liable to be cut off by the sudden urgent "pee-pee-pee-peep" of the relentless digital timer. The jovian north polar ammonia paper was interrupted just as the speaker overlaid two viewgraphs showing the difference between two models — but he persisted and delivered his conclusion.

The next paper was of considerable interest to me because it dealt with the survivability of terrestrial organisms in the jovian atmosphere — the subject of the controversial "Star Tar In the Jupiter Jars" (ASTRONOMY, August 1984).

"This paper examines the possibility" began Carol Stoker, "that terrestrial organisms introduced by a hypothetical spacecraft" (here she could not resist a grin) "could survive in the jovian environment. We've considered only the absolute minimum requirements: their need for liquid water, temperatures between −10 and 100 Celsius, and metabolizable organic compounds." Any such organisms would also need time to grow, and of course, would not be able to live unless they came in contact with food.

"We have produced a numerical model," she said, plunging into the assumptions inherent in the model: the organic foodstuff or "tholin"-produced photochemistry and lightning, rates of diffusion, and numerous constraints they had placed on the problem.

Stoker covered every possible objection before it could be raised — and the main points came only after the timer had sounded: "Jupiter can maintain a microbial biosphere comparable to a terrestrial aquatic environment," said Stoker, "and the biomass would be considerable," reaching a steady state about one year after contamination.

She concluded, "At least for this case, the numbers come out pretty favorable for growth." I asked Stoker afterward if her model wasn't awfully favorable to the bugs; she gave that odd little grin again and said, "Yes, it is, but even if we dilute them by a huge factor, the biomass is enormous."

"By 'huge factor,' do you mean something like a million times?" I asked.

"Yes," she said, "something like that."

After a dinner break, the DPS convened for the public policy session. In past years, this session has been co-sponsored by the Planetary Society and been open to the public. This year, however, it was not. Jeffery Rosendahl explained why: "Three years ago, we were in very serious straits; we now have ambitious activities under way."

The evening was upbeat — and technical. We heard from Daniel Gautier of l'Observatoire de Paris about the European Space Agency's (ESA) ambitious planetary plans, and from Geoff Briggs on current and future NASA plans. Mars Geochemistry Orbiter (MGCO) Project Scientist A. Albee and Laurel Wilkening of the Comet Rendezvous and Asteroid Flyby Mission (CRAF) told what their missions would be and how they would be run.

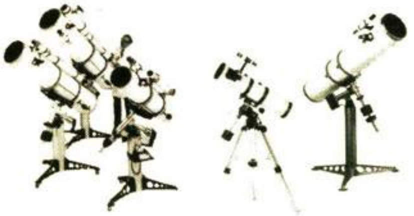
Said Albee, "This mission is a new way of doing business for the space science community," concentrating on "focused science" rather than broad discovery objectives and sporting production-line Earth orbit-derived instruments, fixed-price procurement, and instrument selection after spacecraft procurement. This mission will not grow in cost, which has been fixed at the outset. "These fiscal constraints are real," he added, "and meeting the total objectives of the mission will mean sharing downlink time and higher level data."

There are a lot of places you can buy a telescope.

Orion is the best. Here's why.

Low Prices

Orion's prices are among the lowest you'll find anywhere. Save hundreds of dollars on all the popular brands of telescopes. Big savings on accessories, too. And with our money-back guarantee on every purchase, you can't lose.



Huge Selection

We carry over 1,400 items — astronomical & terrestrial telescopes, binoculars, eyepieces, camera adapters, books & star atlases, electronic control systems, and many unique products you'll really like.

CELESTRON PRECISION OPTICS

Edmund Scientific

Meade

BUSHNELL

AccuTrack™

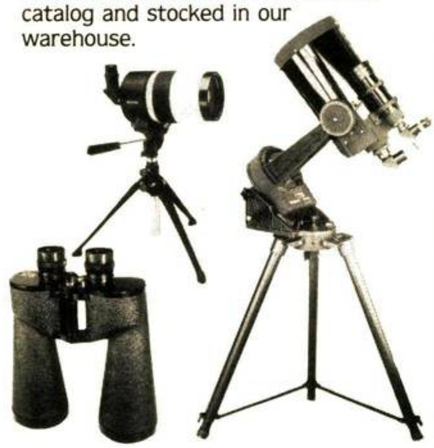
SWIFT

BAUSCH & LOMB

TeleVue

Major Brands

Celestron International. Meade Instruments. Bausch & Lomb. Edmund Scientific. TeleVue. Bushnell. Swift Instruments. Every major brand of telescopes and accessories available is listed in our catalog and stocked in our warehouse.



Free Catalog

Our giant catalog is filled with all the major brands of telescopes, complete accessory listings, and lots of helpful information to make your selection easier. Complete price list, of course. Why not call or write for your copy today?

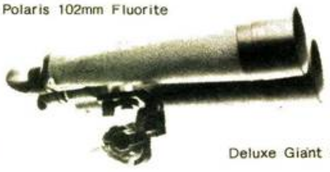
NEW CELESTRON SCOPES NOW AT ORION!

Super Polaris C-8

Polaris 8"f/5 Newtonian

Polaris 102mm Fluorite

Sky Sensor Computer Control



Deluxe Giant 20x80's

Honest Advice

We want to save you money, so we're happy to tell you what NOT to buy, if we feel a product you want is not right for your needs. We promise to never recommend a product just to make a sale. And if we don't have what you want, we'll suggest another company where you can find it. Let the telescope experts at Orion help you with all your telescope questions.

Toll Free! **800-447-1001**

IN CALIF. 800-443-1001

Serving amateur astronomers worldwide since 1975.

ORION
TELESCOPE CENTER
A division of Optronic Technologies, Inc.
P.O. Box 1158-A
Santa Cruz, CA 95061

"Another important mission that's getting nearer is the Space Telescope." Richard Goodie, a soft-spoken astronomer, told the planetary scientists what this instrument will be able to do and how to get a piece of the action.

He was blunt: "ST has very limited hands-on capability," he said. After submitting your observing program, "there's very little to do but sit in your office and wait for the data tapes to roll in." ST will change the way astronomy is done, "because it takes no observing skill to use the ST." He concluded with a few caveats on planning guest observer programs: "You will be coming into a field in which a good deal of the obvious work will have already been done by guaranteed time observers."

While Hawaiians enjoyed their tropical climate, DPS scientists began the following day with a tutorial on heat flow from the interior of Io. Io's internal heat drives the volcanoes, but speaker Dennis Matson noted, "this Io heat flow business is getting complicated." He called attention to the gross similarities between Io and our Moon. The two bodies have the same diameter and mass within about five percent, but the Moon is pretty much dead, while Io most definitely is not.

One of Io's volcanoes, Loki (admittedly the largest), averages 100 times the energy output of all terrestrial volcanoes! The problems begin with too much heat. Some 7x10^{13} watts per second escape from this closest of the Galilean satellites, mostly from its volcanoes. Models based on tidal heating account for only half the energy.

The problem hinges, of course, on the interior of Io — whether it's liquid or solid, layered or mixed. The discrepancy also places limits on how Io's orbit could have changed over the last few hundred million years, and even constrains the interior structure of Jupiter.

After a full day of papers, a cocktail party was held on the lawn — the bar was an imitation thatched hut — followed by the annual banquet. It was pleasant talking, while gleaming Venus set in the west and the nearly Full Moon rose over Mauna Kea in the east. But the talk was not all of planets: "My wife is coming over here for two days — which island should we visit, Kauai or Maui?"

As dinner plates were cleared away, Tom McCord announced two newly-created awards. The first was the Urey Award, in honor of Harold Urey — a *name you may remember from the* Apollo moonwalks. Freita Urey, Dr. Urey's widow, awarded the prize to Dave Stevenson. She told of her father showing her Comet Halley when she was a small girl, and how in ten years "reach for the Moon" mutated from a phrase meaning a fantastic notion to reality.

The other award was the Kuiper Prize, which honors the memory of Gerard Kuiper. The prize was awarded to Eugene Shoemaker by Sarah Kuiper Roth. "I'm sure that Gerard would have been delighted by this gathering," she said. "When Gerard was a boy of about 12, his grandfather gave him a telescope, and that was the beginning of everything" for a man who went on to become the founder of modern planetary science and was responsible for siting a major observatory on Mauna Kea!

The next day, after a quick lunch of curry and kabobed vegetables at a nearby Indonesian fast food restaurant, I hurried back for the Kuiper Prize lecture. Shoemaker sketched a picture of a solar system in which comets played an important role. "I think Kuiper was close to the mark in his understanding of the origin of the comet cloud," he declared, "so let me tell you very briefly what the concept was."

Hawaii is a natural laboratory, with volcanoes, ocean, clean dark skies, and distance from other land masses.

The comet cloud, a huge reservoir of pre-comets far from the Sun, was Jan Oort's idea, "but Kuiper realized a distant comet cloud could have formed closer to the Sun and then been perturbed outward. He saw that comets could best be formed in the outer solar system. As Kuiper conceived it, Pluto perturbed the comets out to the Oort Cloud. It turns out the mass of Pluto is totally negligible, but we have good reason to think the comets formed in the vicinity of Uranus and Neptune, and that Uranus and Neptune formed largely from the accretion of small bodies."

The picture Shoemaker painted of the genesis of the comet cloud was dramatic and sweeping. "The starting mass of condensed material was greater than the present mass of Jupiter," he said, "and contributed considerable mass to Uranus and Neptune." Some of these bodies were perturbed inward to the inner solar system. "The Moon got the business knocked out of it," he noted.

"Half the objects that we call asteroids, I believe, are defunct comets. In the jovian system, the normal interpretation is that we see a gradient in the nebula from which they were formed," so the inner satellites are rocky and the outer ones icy. "But an easier explanation is that all the satellites started out looking like Ganymede and Callisto, but the ices of Europa and Io were removed by a heavy bombardment of comets.

"If the bombardment was rough at Jupiter, then at Saturn it was even worse. The inner saturnian satellites — all the small ones — are the debris remaining from collisions that knocked the original satellite system apart. Every satellite from Rhea on inward would have been knocked apart and re-accreted. Mimas may have been smashed and re-assembled eight to 10 times."

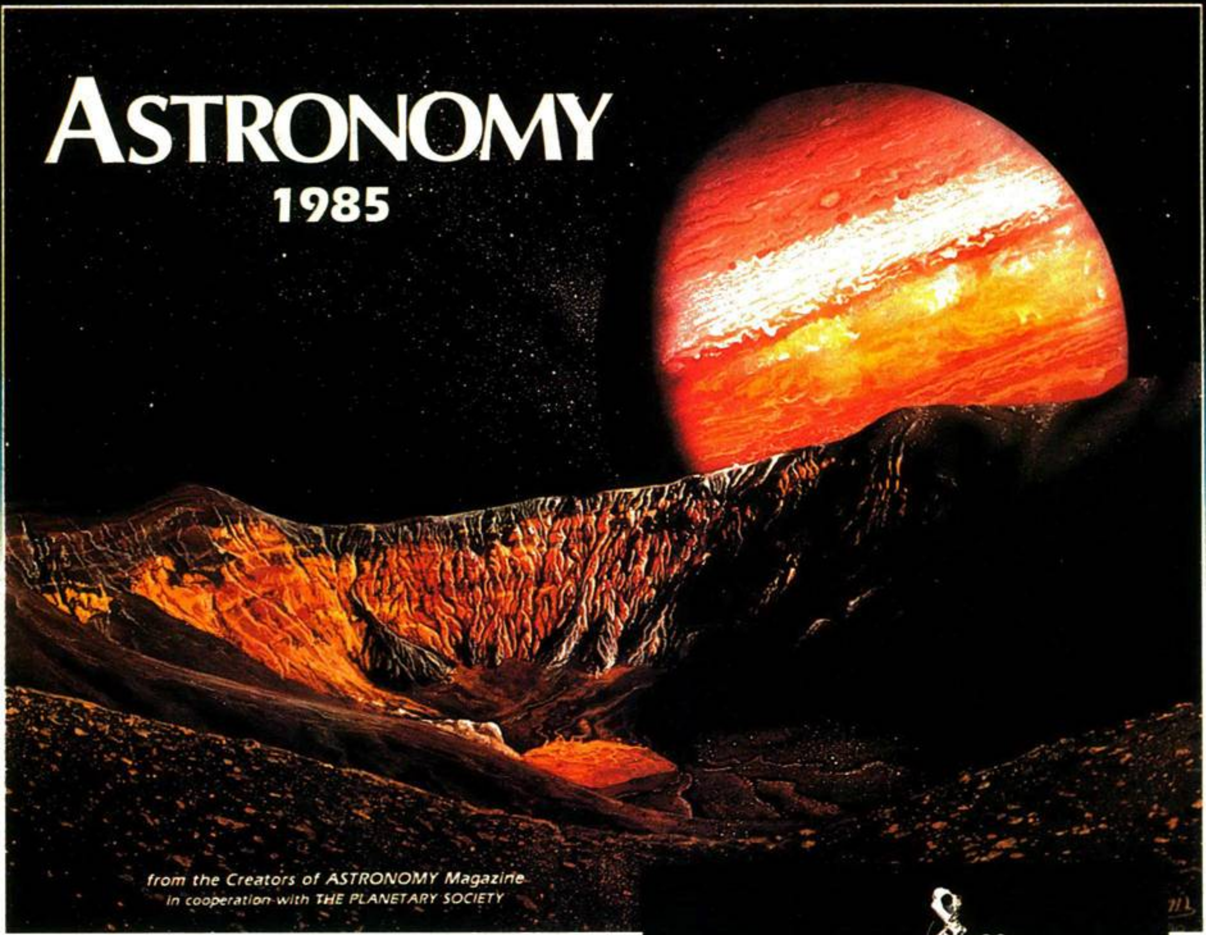
Ideas such as these represent a fairly sweeping rewrite of early solar system history — but are valuable because they can be tested against observational evidence. The Urey Lecture dealt with the "stuff" of the universe. "Consider the conventional wisdom of planetary modeling," said David Stevenson. "Planetary constituents are 'gas,' 'rock,' or 'ice'; these classes are meaningful at the temperatures and pressures in the interior of a planet, and gravity acts to put the heavy stuff at the center."

Urey was the first to grapple with planetary interiors. "You have to go back to his papers to see the power and originality of his science," said Stevenson, holding a copy of Urey's seminal 1952 book *The Planets*. Inspired and impressed by the pioneering planetary astronomer, Stevenson said of Urey, "His greatest contribution was scientifically imaginative work on ill-posed problems." When planetary astronomy was the poor stepchild of stellar astronomy, the questions that a scientist asked might have been problems for which there were no meaningful scientific answers.

Since it was Hawaii, the 1984 DPS Meeting formally concluded with a luau beside the lagoon. Amid flaming torches, the hotel staff barbecued a pig and spread an extravagant feast before us. I sampled a bit of everything — lomi lomi, poki, haupia, laulau, endless salads, and kalua pig — then watched the hula performance. Finally, in true DPS fashion, I rounded out the evening with an hour-long slide show by geologist Tina Neal on recent Hawaiian volcanic activity.

This year, the DPS Meeting was only half the attraction. It was followed by a three-day-long Conference on the Origin of the Moon. But that's a story I'll tell another time.

— *Richard Berry*


ASTRONOMY
1985
from the Creators of ASTRONOMY Magazine
in cooperation with THE PLANETARY SOCIETY

Enjoy the wonders of space every day in the year!

ASTRONOMY's 1985 calendar takes you from the volcanic surface of Io to the ruddy swirls of gaseous nebulae to the stately pinwheels of spiral galaxies in 13 fabulous images of the wonders of the cosmos. Not simply a useful reference, this calendar presents all the beauty and variety of space for your wall. Each big 11" x 14" picture is accompanied by a brief description and a mini-essay, and is printed in full color, ready for framing at the end of the month. For picture impact, reproduction fidelity, and overall quality, we think this is the best calendar ASTRONOMY has ever created!

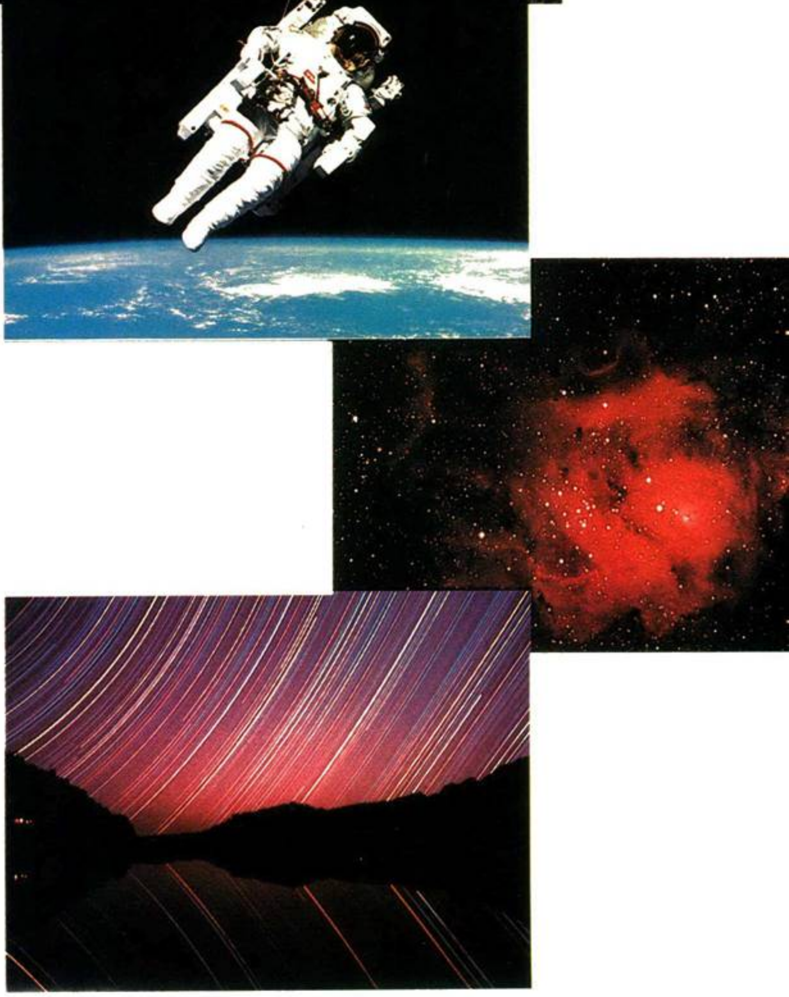
- Full color printing on heavy-weight paper
- Extra-heavy cover is laminated for durability
- Over 300 celestial events, anniversaries and holidays listed
- Room for your notes on appointments and special events
- Bonus picture: The Night Face of North America!

$7.95 **Includes shipping and handling (foreign orders add $1.50)**

Gift givers! Buy 3 and get a 4th one FREE!

Please allow 4-6 weeks for delivery

To order, use the AstroMedia order form bound into this magazine or send to AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202.



Meet the people who help us reach for the stars...

THE BAUSCH & LOMB ASTRONOMICAL ADVISORY COUNCIL

When a company is truly dedicated to manufacturing only the finest products, they must reach beyond normal standards of evaluation. The name Bausch & Lomb enjoys a worldwide reputation for optical excellence, but rather than rest on past laurels, we rely on a team of leading authorities in the field of amateur astronomy to provide us with expert and objective guidance.

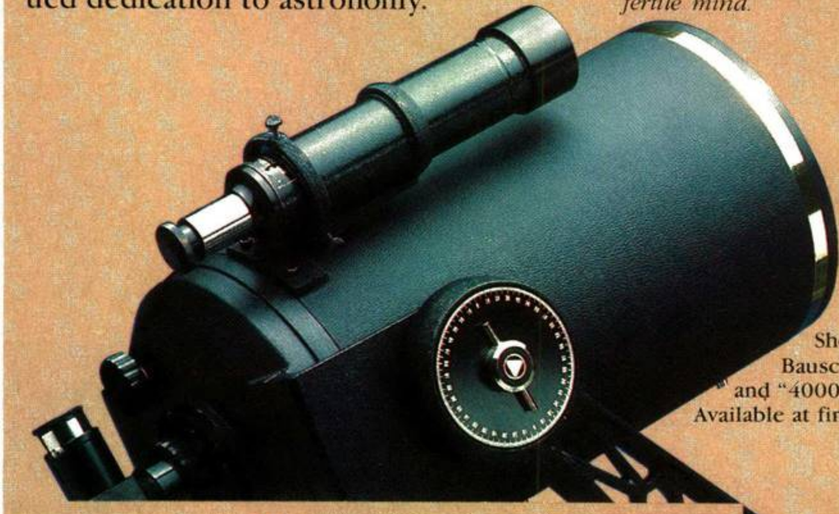
The Advisory Council serves as a valuable link toward fulfilling the needs of our customers, and as testimony of our continued dedication to astronomy.

Ralph Dakin
Retired Bausch & Lomb Optical Engineer. The famous Dakin-Barlow lens is a product of his fertile mind.

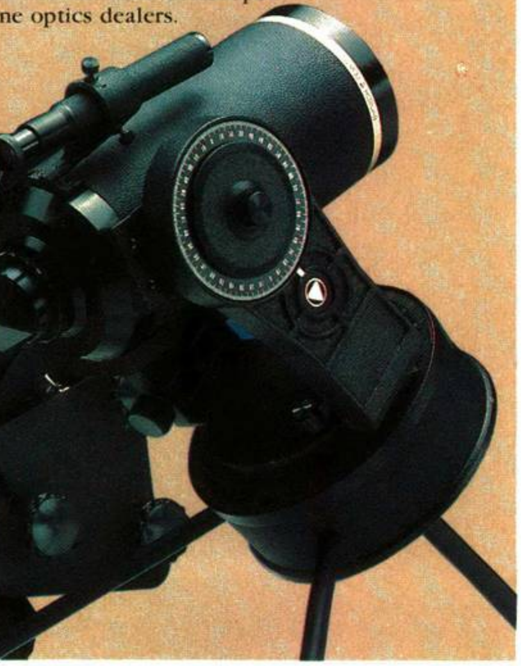
Mary Firth
Expert astronomer and astro-photographer with over 20 years experience. She is a board member and co-founder of the famous Polaris Astronomical Society.

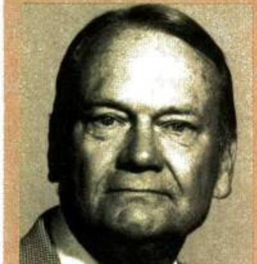
George Keene
On staff at Eastman Kodak, Rochester, NY. Senior Engineer on LANDSAT project. Expert on telescopes and astro-photography. He authored the book "Star Gazing With Telescope and Camera."

BUSHNELL
DIVISION OF **BAUSCH & LOMB**
2828 E. Foothill Blvd. Pasadena, CA 91107 (213)577-1500



Shown:
Bausch & Lomb Criterion "8000"
and "4000" Astronomical Telescopes.
Available at fine optics dealers.





Richard Nelson
In the early 1960's he founded the Optical Craftsman Company which manufactured the highest quality reflecting telescopes. He is an expert on the heavens.

Fred Espenak
A professional infrared astronomer with NASA, also an accomplished "amateur" astronomer and astrophotographer. Along with George Keene, he leads solar eclipse tours.

William Douglass
Retired Pan Am Flight Engineer. President of Southern Cross Astro Society, in Miami, Florida. Expert amateur astronomer. Specializes in solar research.

focus

CAMERA INC.

4421 - 13th Ave., Brooklyn, N.Y. 11219
Dept. 03AS

ENJOY ASTRONOMY AT DOWN TO EARTH PRICES

★ *Large Inventory* ★ *Immediate Shipping*
★ *Huge Savings* ★ *Personalized Service*

CALL TOLL FREE Except AK, NY & HI **800-221-0828** For Orders Only

Ask for Joel or Mark our telescope experts For Information, AK, NY & HI **718-436-6262**

Satisfaction Guarantee: refund or exchage within 14 days (less shipping) if returned in original MINT CONDITION with all papers (as shipped)

Customer Service 718-871-7608

FREE Professional Optical Maintenance Kit With Purchase ($18 Value) w/this clipping

FOCUS CAMERA & ELECTRONICS has been serving customers nationwide With all their photographic needs, for over 16 years, with a solid reputation for integrity. We invite you to join our hundreds of thousands of satisfied customers. Give our knowledgeable sales staff a call TODAY! **AND SAVE!**

CELESTRON

PRECISION OPTICS

WORLD'S FAVORITE!

SUPER C8 PLUS

- 8" Aperture
- 480 Power
- Gathers 791 times more light than the eye
- Ultra precise gear drive

Complete outfit w/Oculars, Finderscope etc. as supplied by the manufacturer.

CALL

SUPER POLARIS C8 W/TRIPOD. $779

Sky Sensor Computing Control	399
Comet Catcher Jr.	229
Celestron Comet Catcher	299
Case for Comet Catcher	38
C65 Spotting Scope	139
Delux Zoom Ocular	92
C90 Spotting Scope Outfit	319
C90 Astro Telescope w/Clock Drive	499
C5 Telescope	769
C6 Newtonian Reflector	549
C11 Telescope	Call

BEGINNER'S SPECIAL: ASTROPHOTOGRAPHY OUTFIT

- Top-ranked SLR Camera MINOLTA X-700, CANON AE-1 Program or NIKON FG
- CELESTRON C90, 1000MM Lens
- SLIK Delux Rugged Tripod
- Camera Adapter • *T-Mount*
- Carrying Case
- 6 Piece Outfit $495.90

CELESTRON ACCESSORIES

C8-C90 Adjustable Tripod	159.90
Photographic Tripod	78.00
2X Barlow Lens	26.90
Celestron Sky Maps	13.90
Solar Filter	99.50
Wedge C8-C90	59.90

Large Assortment of Oculars in Stock

CELESTRON TELEPHOTO LENSES

(Requires T-Ring; specify camera brand)

C90	Telephoto 1000mm	255
750mm	Telephoto	502
750mm	w/Special Coating	613
1250mm	Telephoto	454
1250mm	w/Special Coating	530

Complete with all accessories

★ CELESTRON ANNIVERSARY SALE ★

C80 REFRACTOR

- 910mm Effective focal Length
- Gathers 130X More light than the human eye
- 1¼" Ocular for Wide Field of View
- Equatorial Mount w/Circle Settings

$459.90 W/tripod

FIRSTSCOPE 80 w/Azimuth Mount & Tripod $339.90

Super Polaris 80mm Refractor (accepts Sky Sensor) **$595.00**

ACCESSORIES:

Quartz Motor Drive	$109.00	2X Barlow Lens, Dlx	$52.00
Polar Axis Finder w/Illuminator	$58.00	Piggy Back Mount	$34.00
Sky Maps	$14.90	Camera Adapter	$26.90

TOP RATED CELESTRON C6 NEWTONIAN

- Huge Light Grasping Ability
- Multicoated for 20% Brighter Images
- 750mm Effective Focal Length
- 28" long, 50 lbs
- 45Xmore light Gathering Ability than the Human Eye

$549.90 w/Tripod
& Free Subscription to "Deep Sky"

Nikon BINOCULARS

The Famous Nikon Optics Are Your Best Assurance For Clear And Crisp Images

9x25-CF Compact	49
7x35-E High Eyepoint	116
10x35-E High Eyepoint	128
7x50 Standard High Performance	149
10x70-IF	288
8x20 Roof Prism	112
Nikon Spotting Scope with 20x Eyepiece	198
8x30 Rubber Coated	156

ZEISS

- THE ULTIMATE IN PRECISION
- MULTI-COATED T* OPTICS
- UNSURPASSED BRILLIAMT BRIGHTNESS

6x20B/IF **160** 20B/CF	**187**	8x30 B/CFT* Armored	**396**
8x20IF	**168**	10x40B/CF T*Dialyt	**449**
10x25B/CF	**197**	7x50B/IF **596** 7x42B/CF	**422**
8x30 B Dialyt Standard B/CF/T*	**367**	8x56B CF T* Armored	**536**
8x30 B/IF Armored	**337**	10x40B/CF Armored	**478**
		15x60 CF T* Porro	**827**

Leica TRINOVIDS

Conditional Lifetime Guarantee

- The Singular Choice of Those Who Demand the Absolute Best
- Perfect for Eyeglass Wearers
- Conditional Lifetime Guarantee
- Climate Dust Spray — Waterproof
- Armored Models are Resistant To Impact and Shock
- Every Detail Becomes Vividly Real

10x40-B	414*	8-20-BCA Armored Compact	175*
10x40-BA Armored	448*	10x25-BCA Armored Compact	189*
7x35-B	284		
7x35-BA Armored	308		

** $25 or $100 Rebate*

CELESTRON

PRECISION OPTICS

GIANT BINOCULARS

- Perfect for astronomy & low-light viewing
- Glare-free viewing & no eyestrain
- Exceptional image quality
- 25 year warranty

11x80	199
20x80	219
30x80	229

BUSHNELL

DIVISION OF **BAUSCH & LOMB**

SPACEMASTER OUTFIT:

- SPACEMASTER 60mm
- 15-45X Zoom Eyepiece
- Table Tripod
- Attache Case

$214.90 Complete Outfit

Discoverer with 15x-60x Zoom Eyepiece	209
Camera Mount	24
Spacemaster #1800	139
Eyepieces	All in Stock

BUY SOMETHING WORTH LOOKING INTO THE CRITERION 4000

BUSHNELL DIVISION OF **BAUSCH & LOMB**

- Compact 7"x7"x14" weighs 10 lbs.
- Includes Finderscope, 2 Oculars & Adjustabale Legs
- 1200mm Effective focal Length
- With Electrical Clock Drive

$475.90

Criterion 6000 Telescope Kit			$789.00
Criterion 8000 Telescope Kit			$939.00
Criterion 4000 Telephoto Lens			$289.00
Porro Prism	$37.00	Nebula Filter	$71.00
2X Barlow Lens	$27.00	Camera Adapter	$21.00

CATALOG
OUR NEW 96 PAGE WINTER CATALOG FEATURING THE LATEST IN PHOTOGRAPHICS & ELECTRONICS $3

Authorized Meade Dealer

A WHOLE LOT MORE THAN MEETS THE EYE

LIFETIME WARRANTY

SUPER SPECIAL! BEST SELLER! **199⁹⁵** w/CASE

THE IDEAL SPOTTING SCOPE FOR VIEWING HALLEY'S COMET

MEADE 870

- 1000MM EFFECTIVE FOCAL LENGTH
- 49X MORE BRIGHTENSS THAT THE HUMAN EYE
- 40X & 83X EYEPIECES INCLUDED

3.5" Model 97D Spotting Scope with 5x24mm Viewfinder

#97D, 1000M F11 with Finder, Star Diagonal 2 Eyepieces (40X, 89X)	**$295.90**
Erecting Porro Prism	**$46.00**
Table Tripod	**$34.00**
#1070 4", 145X Human Brightness, F/10 Focuses Down to 15 ft.	**CALL**

INTRODUCING THE FAMOUS SCHMIDT-CASSEGRAINS from

Authorized Meade Dealer

8" MODEL 2080

- Best Seller Astronomical Telescope for the Serios Amateur
- Tremendous Light Gathering Capability
- Supplied w/Electric Motor to Automatically Track Astronomical Objects

Outfit Includes Star Diagonal, 2 Eyepieces (80X & 222X), & 6x30 Finderscope **$875.90**

8" **#2080/LX** Features **ULTRA-PRECISION** Drive System **CALL**

8" **#2080/LX2** With High Transmission Starbright Coating, 7mm (286 Power) Ocular & 8 x50 Finderscope **$1079**

#2044 4" With 9mm & 25mm (111X & 40X) & Table Tripod **$697**

ACCESSORIES:

Wedge	**$65.00**	8" Field Tripod	**$198.00**
Sky Map	**$15.90**	Tele-Extender	**$25.00**
8" Solar Filter (For Safe Observation of the Sun)	**$198.00**		

MEADE DEEP-SPACE SERIES:

DS-10, 10" w/46X Eyepiece, 46" long, w/Equatorial mount & Tripod Legs **$669.90**

DS-16, 16" w/75X Eyepiece 68" long, complete Kit ..... **CALL**

SWIFT

SPOTTING SCOPES & BINOCULARS PAR EXCELLENCE

(All w/Tripod Socket)

11x80 GIANT CF	**$179.90**
20x80 CF WIDE ANGLE GIANT	**$195.00**
Photographic Tripod	**$44.90**

SPOTTING SCOPES:

#840 Lynx 20-60 x65 Spotting Scope			**$439.90**
#841 15-60 x60 Spotting Scope			**$229.90**
#844A 20x60 Armored Commando Spot.Scope			**$179.90**
Swift Tripod	**$54.00**	Attache Case	**$39.00**
Tubular Case	**$19.00**	Camera Adapter	**$18.00**
Skylight Protective Filter			**$8.90**

FOCUS CAMERA INC. 4421 13 Ave., Brooklyn, NY 11219
Dept. 03AS

Orders: 800-221-0828
Information: 718-436-6262
Customers Service: 718-871-7609

Orders shipped promptly—Mastercard, Visa gladly accepted. You may use your American Express card. No surcharge on Visa/Mastercard. We accept C.O.D. orders. Add estimated charge for shipping, handling & insurance. Written inquiries welcome. Not responsible for typographical errors. HOURS: Mon-Thurs 10-7/Fri 10-3/Sun 10-6. All merchandise avail. at prices shown while supplies last.

ASTRONOMY
In Focus

Solids, Regular and Otherwise

Sir / I was dismayed at a number of geometrical misconceptions in Sten Odenwald's article, "Does Space have More than Three Dimensions?" (November 1984). First, the Euler number C − E + F is 2 for any polyhedron that has no holes in it — not just the regular polyhedra. This is a topological invariant of the sphere, into which any such polyhedron can be deformed (which is why there can't be holes; if it deforms into a torus, $C - E + F = 0$). The fact that there are only five regular polyhedra has nothing to do with Euler's formula. The generalizations to higher dimensions of Euler's formula (the Euler number is 2 or 0 in alternate dimensions) also have nothing to do with the number of regular figures in each dimension. It is the same (0) for dimensions 2, 4, and 6, but the number of regular figures in each is, respectively, infinity, 6, and 3.

Second, in the table on page 70, it is stated there are only five regular polygons. There are, of course, infinitely many.

Third, why do the extra dimensions introduced in particle physics have to be *spatial* dimensions? There are many other sorts of dimensions; after all, a dimension is just an independent variable. It takes six dimensions to determine the state of a single (classical) particle (three for position, three for momentum), but nobody is suggesting that, as a result, particles "inhabit" a six-dimensional space. (Yes, I know about state space, but it isn't *spatial.*)

Fourth, I was genuinely confused (probably due to inadequate background in physics) by the assertion that the inverse square law of gravitational attraction depends on the existence of three spatial dimensions. After all, the motion of a two body system occurs in a single plane, so it can be modeled in two spatial dimensions. I would think an appeal to electromagnetic theory would be more appropriate. Cross products and the right hand rule do require the use of exactly three dimensions.

I apologize for the overall negative tone of this letter. I enjoy the magazine and found Dr. Odenwald's previous article on the decay of the false vacuum fascinating. I hope the above items represent a mere temporary lapse, and not nearness to my own field of expertise.

A.D. Elmendorf
Ithaca, NY

Mr. Elmendorf: Euler's original formula can be used to enumerate the number of regular solids in 3-space and also for finding the number of regular polytopes in n-dimensional space. This procedure formed the backbone of my brief review on the nature and numbers of regular polytopes in 3-, 4-, and n-dimensional space. I did not devote more space to an in-depth discussion of just how Euler's Formula, or Poincare's generalization of it, is used to enumerate the number of regular solids in a space of arbitrary dimensionality. I merely attempted to give the reader a flavor of how the dimensionality of space has physical consequences that extend far beyond the obvious ones. For more on the subject, see Geometry and Imagination *by David Hilbert and S. Cohn-Vossen.*

Your second point is, of course, absolutely correct. The table appearing on page 70 should show an infinite number of regular polygons that can be inscribed in a circle.

In response to your third comment, the point of my article is that the extra dimensions are manifestly spatial in character, since that is the role they play in the generalized metric tensor that describes space-time. We may call these "spatial" dimensions because those are the "slots" they occupy in the fundamental metric tensor which defines the geometry of space-time.

Finally, the dimensionality of space does influence the behavior of gravity. J. Richard Gott III, in a letter to Scientific American *in October 1980, summarized the case for gravity in "Flatland" by showing that gravity is impossible in 2-D universes. Neither the action-at-a-distance character of gravity nor gravity waves are allowed solutions to the field equations of general relativity in such a world.*

The additional terms that appear when considering more than three spatial dimensions let gravity behave in many different ways. The prospect raised by Supergravity theory is that these extra degrees of freedom may be taken up by other kinds of physical fields in nature — fields corresponding to the strong, weak, and electromagnetic forces. Only sub-atomic particles experience their affects directly — not people, planets or galaxies!

Sten Odenwald
Naval Research Laboratory
Washington, DC

Heading for Halley

Sir / HELP! I hope to travel south for the best viewing of Halley's Comet. Travel agencies are already offering comet-viewing excursions. One lists trips to Mexico throughout March 1986. Another offers trips to South America and New Zealand in the first half of April. I need to know when the comet is expected to put on its best show.

Alida Sverdsten
Cataldo, Idaho

— Halley will be most impressive after its closest approach to the Sun in February 1986. As the comet nears Earth in late March and early April, its tail could be more than 30° long and it may be as bright as second magnitude. Since the comet is near its

southernmost point around this time (see pages 12 and 13), the farther south you go the better the show. From New Zealand, Halley will be located near the zenith and will be visible all night long!

But in that area the prospects for weather and sky darkness are better for the central desert of Australia. Incidentally, Steve Edberg — JPL's Coordinator for Amateur Observations for the International Halley Watch — reports at least 16 expeditions have been planned.

Ritchey Biography

Sir / I am collecting material for a full-length scientific biography of George W. Ritchey (1864-1945) — the noted American telescope maker and astronomer. I have seen nearly all his published scientific papers and many letters that he wrote and received. But I am sure there are other letters, clippings, articles, reminiscences of co-workers, etc. that I have not seen and I would welcome copies of such material. I am especially desirous of obtaining information on Ritchey's family and early life. He was born in Tuppers Plain, Ohio, grew up in southeastern Ohio, then moved with his family to Cincinnati. After marriage, he resided in Chicago, Williams Bay (Wisconsin), Pasadena, Azusa (California), Paris, Washington and finally Azusa again. I would be particularly interested in hearing from surviving relatives of this great American scientist who might have information about his life and family.

Donald E. Osterbrock
Lick Observatory
University of California
Santa Cruz, CA 95064

The Quasar "Bridge"

Dear Sir / I was most interested to read the article on quasars in the October issue. Particularly impressed by the apparent non-Doppler relation shown by the NGC-4319/Markarian 205 pair, I was on the verge of changing my view of this situation when I remembered a similar phenomenon seen closer to home. I'm referring to the "black drop" effect visible at either end of a solar transit by Mercury or Venus. When this happens, a dark "bridge" appears between the disk of the planet and the Sun's limb. Could the big challenge to redshift distances be something similar?

J. Pollard
Hertfordshire, England

Mr. Pollard: Since Dr. Sulentic's article appeared, University of Hawaii astronomers Gerard Cecil and Alan Stockton have published a paper in which they claim the galaxy and quasar are unrelated. They contend that the "bridge" is real, but it connects the quasar with a background elliptical galaxy with the same redshift as Mkr 205. (See December 1984 AstroNews.) Their conclusion agrees with the objects' redshifts and supports the conventional view of quasars as extremely distant, powerful centers of otherwise normal galaxies.

HALLEY.BAS for Epoch 2000

Last month's computer program HALLEY.BAS gave coordinates for epoch 1950. Those who wish to have epoch 2000 coordinates should add the following five lines to the program to precess the 1950 results to 2000:

```
1263 RP=3.073+1.336*SIN(H1*PI/180)*TAN(M1)
1264 H1=H1+50*15*RP/3600
1265 IF H1>360 THEN H1=H1-360
1266 DP=20.04*COS(H1*PI/180)
1267 Y2=Y2+50*DP/3600
```

You should also alter line 1610 to remind yourself of the epoch:

```
1610 PRINT "EPOCH 2000 COORDINATES:"
```

Behind the Scenes

AstroMedia Joins Kalmbach Publishing

Early this year in a move that came as something of a surprise to us, Kalmbach Publishing Co. acquired AstroMedia Corp. — the company that publishes ASTRONOMY and ODYSSEY, TELESCOPE MAKING and DEEP SKY. Our new owner is a well-established Milwaukee-based publisher of quality hobby magazines: *Model Railroader, Trains,* and *FineScale Modeler.*

What does this mean for YOU — ASTRONOMY's readers? Actually, it means very little. Kalmbach wants us to continue producing ASTRONOMY as we have for the past 11 years. Your issue of ASTRONOMY will continue to arrive on time each month packed with features and helpful articles — and we promise that it will *still* be the world's most beautiful astronomy magazine.

For us, the change is very exciting; it means bigger challenges, new opportunities, and will enable us to place ASTRONOMY before an even wider public than we currently reach. This, in turn, will introduce people who may have never even heard of ASTRONOMY to an exciting hobby that really opens the mind.

And speaking of astronomy, you're probably aware that Comet Halley will soon be visible. We're already planning how ASTRONOMY can provide you the best coverage and observing aids for observing the flyby. In addition, we're publishing a detailed observing guide. It's called (naturally) *Halley's Comet* and will be available this summer in bookstores all around the world — and, of course, through ASTRONOMY. Watch for it. . . .

By the way, our editorial offices will remain here at 625 E. St. Paul Ave. for at least another year before we make a short move across town to the Kalmbach Building. Our circulation and subscription departments may be moving somewhat sooner, but we will keep you posted well in advance of these important address changes.

Sincerely,

Richard Berry

Richard Berry
Editor-in-Chief

P.S. Did you notice our new and improved Star Dome in this month's center spread? I'll tell you all about it next month!

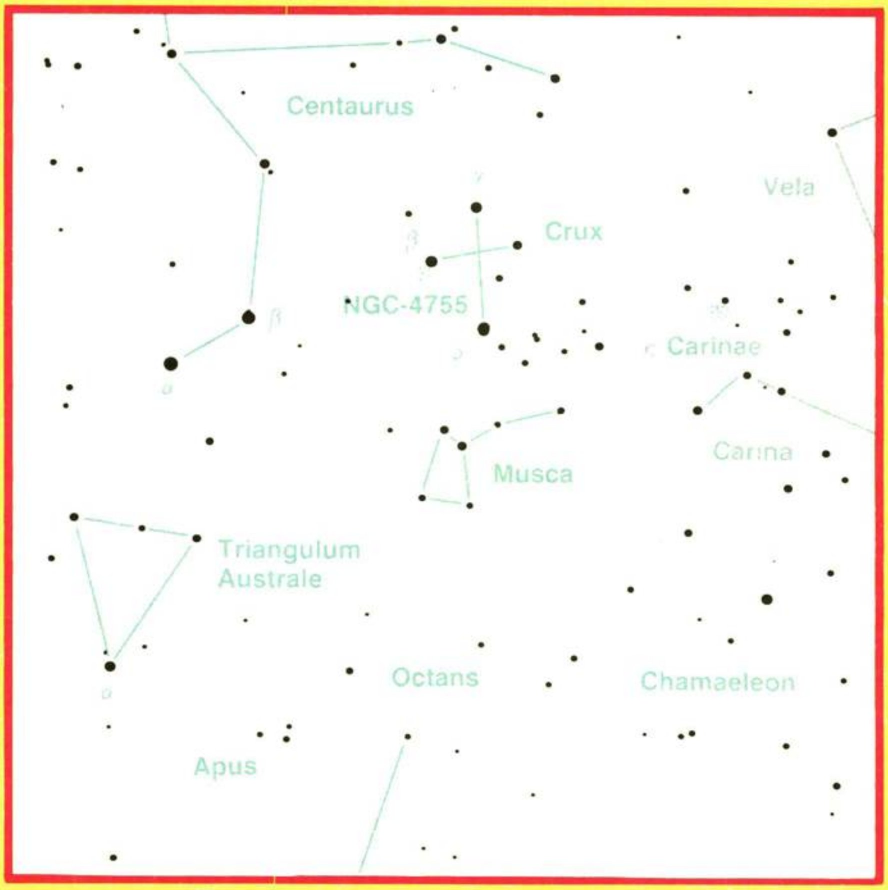
Gazer's Gazette

Stars of the Circumpolar South

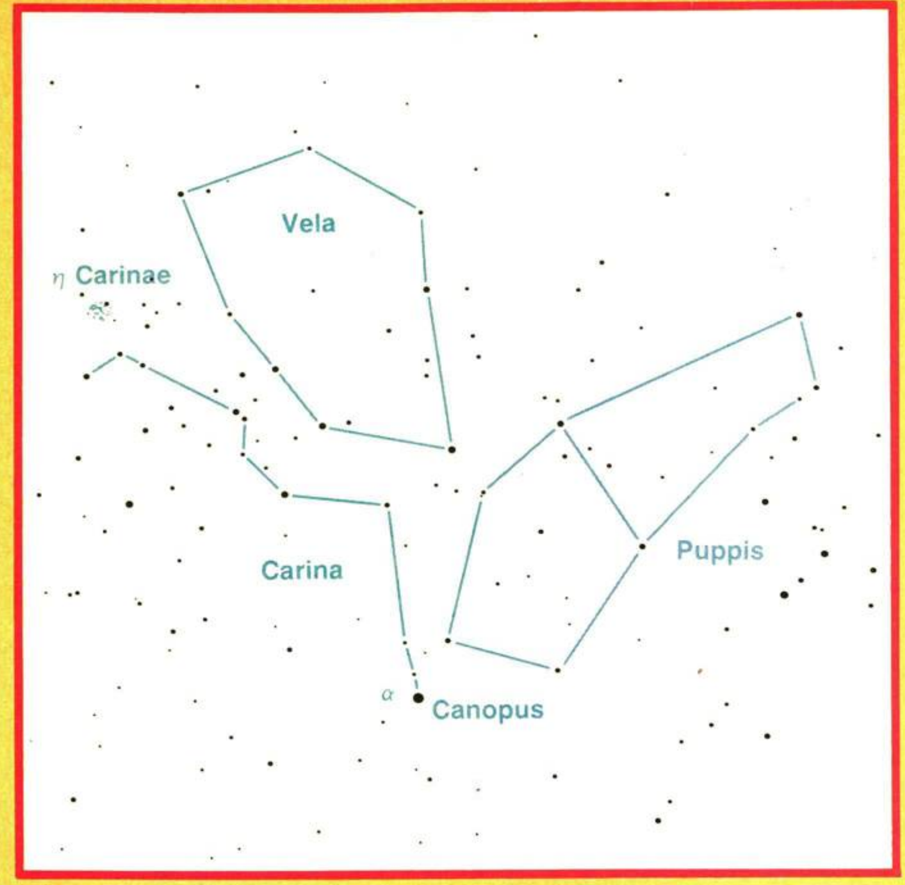
Unlike Polaris in the north, no bright star marks the South Celestial Pole. The imaginary point representing the axis of Earth's south pole is occupied by an unspectacular group of stars known as Octans the Octant. This small constellation boasts nothing better than Sigma (σ) Octantis, a magnitude 5.5 star, as the southern Pole Star — and it lies 52′ away from the true pole. Octans' brightest star is Delta (δ) Oct, a magnitude 4.1 orange star lying 205 light-years distant. Other stars visible to the unaided eye include Beta (β) Oct, a magnitude 4.3 white star; Theta (θ) Oct, a magnitude 4.7 orange star; and Alpha (α) Oct, a magnitude 5.2 white star. But Octans is hardly typical of the southern skies. Southern hemisphere observers enjoy some of the most brilliant constellations in the entire sky. However, before we consider the brightest of the southern gems, let's first explore the dimmer constellations in the vicinity of the Pole.

Chamaeleon the Chamaeleon is an obscure group of stars. Its brightest star, Alpha Chamaeleontis, is a white fourth-magnitude star located 67 light-years away. Star atlases sometimes picture Chamaeleon devouring a nearby constellation, Musca the Fly. Situated just south of Crux, the Southern Cross (which we *will* discuss later), Musca contains three stars readily visible to the naked eye: Alpha Muscae is a hot blue subgiant, slightly variable, with magnitudes ranging between 2.66 and 2.73; Beta Mus is a close double star, whose 3.7 and 4.0 magnitude components are inseparable without a telescope; Delta Mus is a magnitude 3.6 ruddy star some 155 light-years distant.

Adjacent to Musca and Chamaeleon is the tiny constellation Apus, the Bird of Paradise. Three of Apus' stars are naked-eye targets: Alpha Apodis is a magnitude 3.8 orange-red star some 234 light-years away; Beta Aps is a magnitude 4.2 yellowish star lying 109 light-years distant; Gamma Aps, a subgiant orange star



The southern circumpolar sky is filled with a collection of constellations. Octans, at lower center, contains the point around which southern hemisphere stars seem to rotate. Musca the Fly, made up of several third-magnitude stars, is visible to the naked eye. Triangulum Australe (the Southern Triangle) and Crux (the Southern Cross) are fairly bright and easy to see. The diminutive Apus and Chamaeleon, however, are inconspicuous and surrounded by the brighter Carina, Vela, and Centaurus.



The constellations Carina, Puppis, and Vela once formed the ship *Argo Navis*. They were split up, however, and Vela now represents the ship's sails, Carina its keel, and Puppis the poopdeck. Carina contains Canopus, the second brightest star in the sky.

shining at magnitude 3.9, lies about the same distance as Beta.

Across the Pole from Chamaeleon are two more small star groups. Volans, the Flying Fish, contains a number of challenging naked-eye stars. Alpha Volantis, a blue-white star 69 light-years from Earth, softly glows at magnitude 4.2. Gamma Vol is a close double, of fourth-magnitude. Delta Vol is a luminous white star and appears as bright as Alpha, but lies over 15 times farther away. Southwest of Volans is Mensa, the Table Mountain, whose dim stars are difficult to recognize with unaided eyes. The group's brightest star, Gamma Mensae, is an orange-yellow dot with only a 5.1 magnitude.

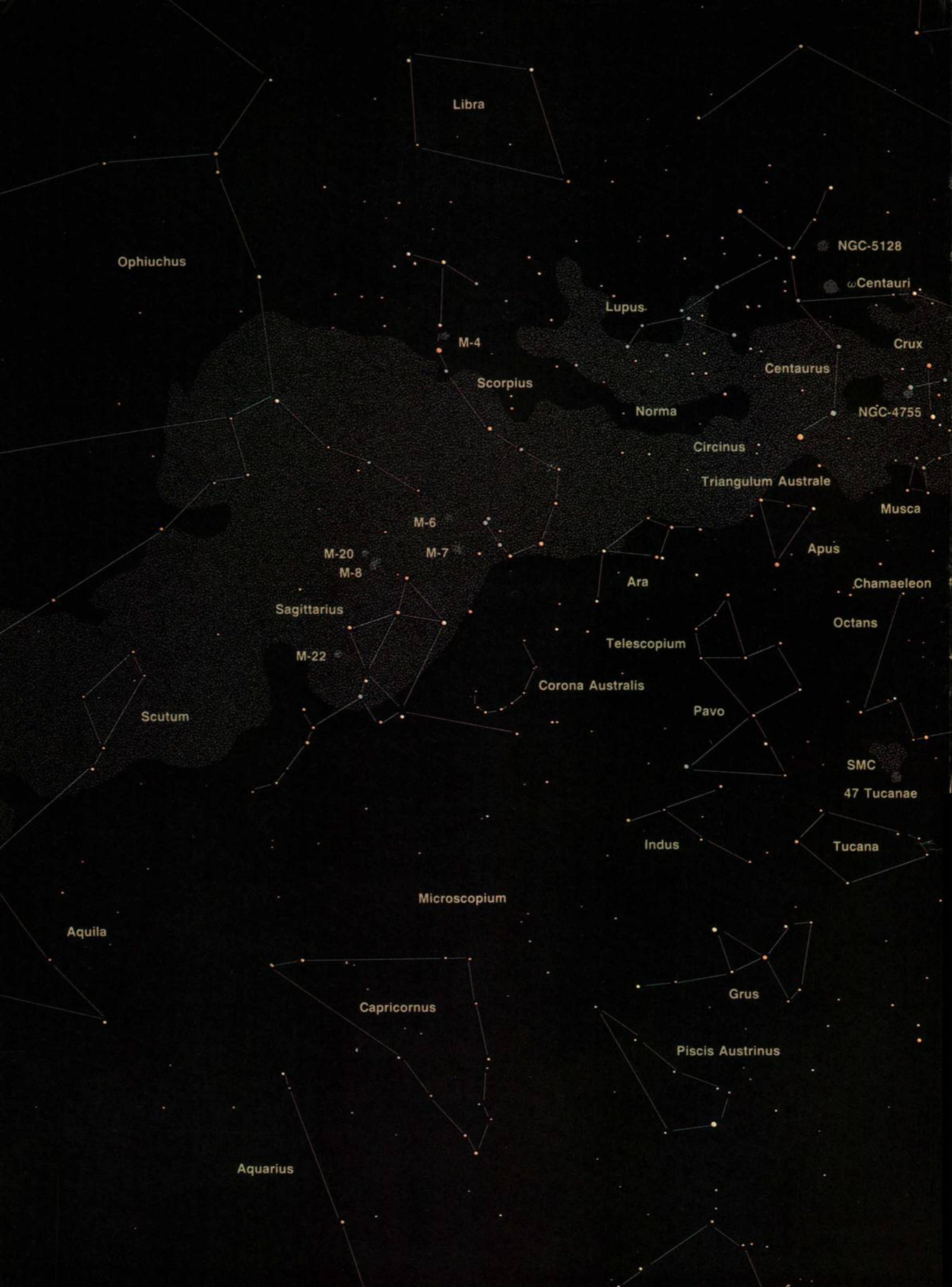
Moving outward from Octans and the south celestial pole, the constellations become larger and more impressive as you reach the star-rich fields of the Southern Milky Way.

The large constellation Carina the Keel, once part of the old sky-ship *Argo Navis*, is loaded with bright and unusual objects. Spanning five hours' of right ascension, Carina contains Canopus (Alpha Carinae) — the second brightest star in the sky. Lying on the western border of Carina — almost into neighboring Pictor — Canopus shines at a dazzling −0.73 magnitude. It is a white subgiant and lies about 200 light-years away from Earth. On the opposite side of this winding chain of stars is Miaplacidus, or Beta Car, still quite bright at magnitude 1.7. It is a blue giant star lying much closer than Canopus, which is intrinsically more brilliant. Tureis, the star marking *Argo Navis'* stern, is also known as Iota (ι) Car. It is a magnitude 2.2 white supergiant lying 650 light-years away. Carina also holds possibly the most spectacular emission nebula (fluorescing gas cloud) in the entire sky. Enveloping the star Eta (η) Car, the Eta Carinae Nebula is plainly visible as a fuzzy patch to the naked eye and is a fascinating object for binoculars.

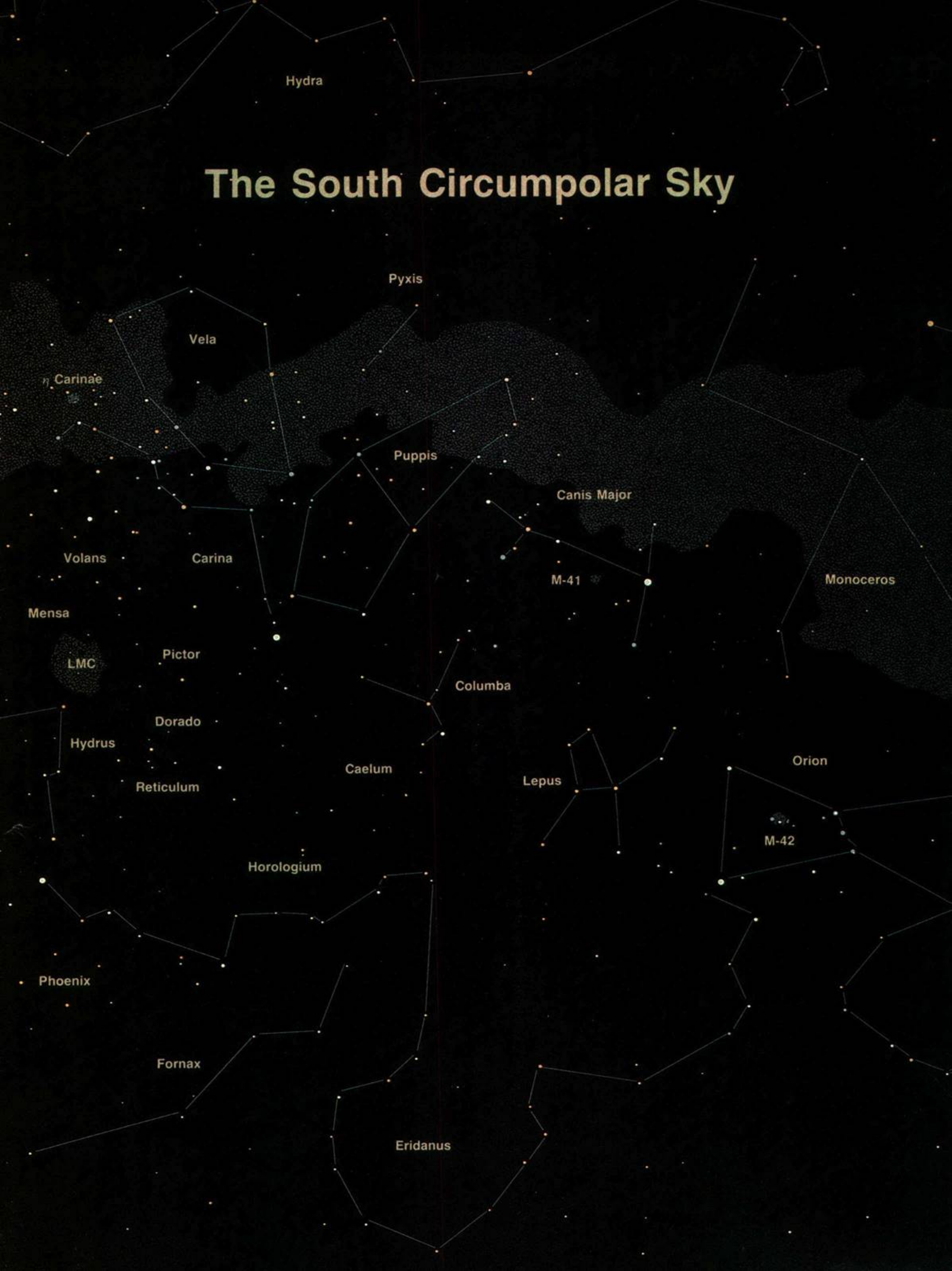
Vela, lying north of Carina, consists of what was once *Argo Navis'* sail. Vela has no Alpha or Beta stars because they were assigned to other constellations when the old constellation Argo divided. Vela lies within the rich part of the Milky Way south of Puppis; its brightest star is Alsuhail (meaning brilliant), or Gamma Velorum, which shines at magnitude 1.8. Alsuhail is a hot so-called Wolf-Rayet star, which is throwing off a shell of glowing gas. Delta Vel, a close double star, shines at second-magnitude and appears strongly bluish-white. Lambda (λ) Vel, a 2.2 magnitude orange-red star, lies some 750 light-years away.

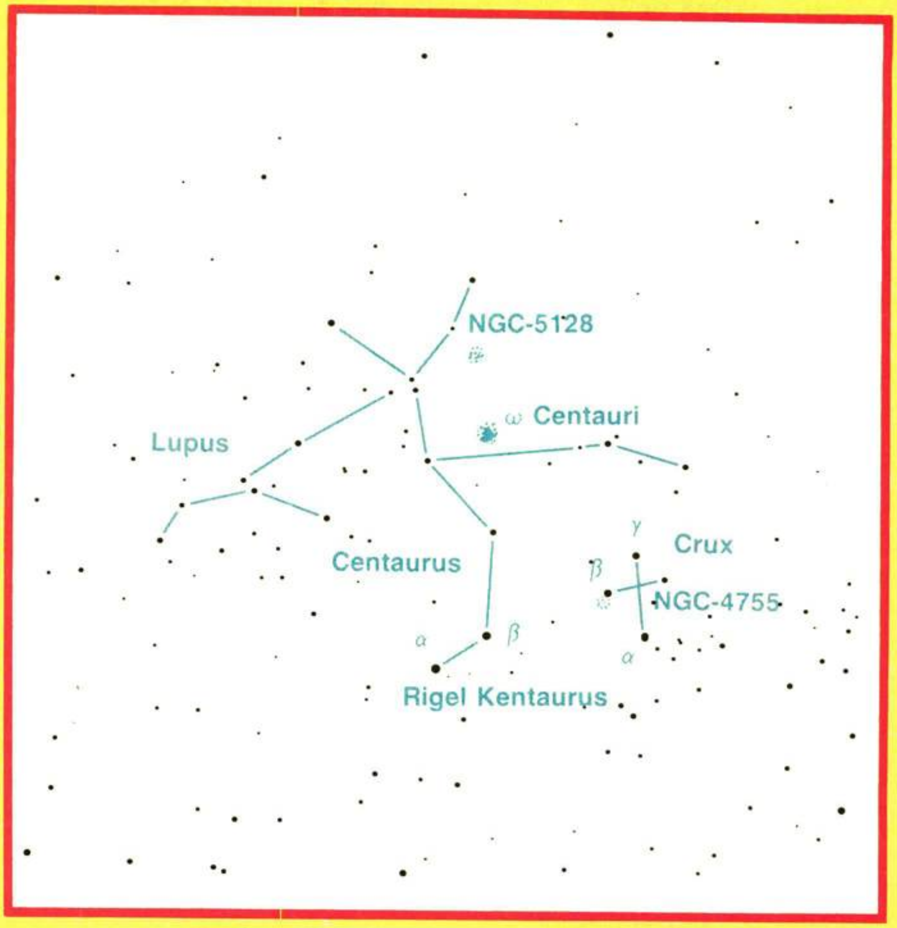
Smack dab in the middle of the Southern Milky Way is the small but brilliant group known as Crux, the Southern Cross. One of the most distinctive and beautiful arrangements of stars in the southern hemisphere, it has five members that make fine targets for naked-eye or binocular viewing. Alpha Crucis, holding down one end of the Cross' long axis, is known as Acrux. It is a close double star with magnitudes 1.4 and 1.9; both stars are hot blue subgiants some 260 light-years distant. On the other end of the axis is Gamma Cru, or Gacrux. This is an unusual magnitude 1.6 giant red star lying 230 light-years off. See how strongly you can detect its ruddy hue with your naked eye or binoculars. Forming the short axis of the Cross are Beta Cru and Delta Cru. Beta is a giant bluish star that is slightly variable, but normally shines at magnitude 1.3. Delta is a hot blue subgiant — also slightly variable — which generally shines at magnitude 2.8. Also found in Crux is Kappa (κ) Cru, a cluster so bright that it has earned a Greek letter for being one of the constellation's brightest "stars." Binoculars show Kappa, designated NGC-4755 and also called the "Jewel Box," as a star-studded group of several dozen shimmering suns.

Following the Milky Way eastward, we find Centaurus the Centaur. This large, extraordinarily rich grouping of stars is without a doubt the most stunning area in the Southern Milky Way. The brightest star in Centaurus is Rigel Kentaurus (Alpha Centauri), which means "foot of the centaur." A blazing −0.01 magnitude star, Rigel Kentaurus is bright because it is the nearest star to the Sun at a distance of just 4.2 light-years. Curiously, this closest star is a near-duplicate of the Sun: a yellowish main sequence star roughly eight percent more massive than Sol. In large binoculars, you may see that Rigel Kentaurus is a double with an orange-colored magnitude 1.4 companion some 22" away. Over 2° from this pair is a third physically-connected star, a reddish dwarf


Libra
Ophiuchus
NGC-5128
ωCentauri
Lupus
M-4
Crux
Centaurus
Scorpius
Norma
NGC-4755
Circinus
Triangulum Australe
Musca
M-6
M-20
M-7
M-8
Apus
Ara
Chamaeleon
Sagittarius
Octans
Telescopium
M-22
Corona Australis
Scutum
Pavo
SMC
47 Tucanae
Indus
Tucana
Microscopium
Aquila
Grus
Capricornus
Piscis Austrinus
Aquarius

The South Circumpolar Sky


Hydra
Pyxis
Vela
η Carinae
Puppis
Canis Major
Volans
Carina
M-41
Monoceros
Mensa
LMC
Pictor
Columba
Dorado
Hydrus
Caelum
Lepus
Orion
Reticulum
M-42
Horologium
Phoenix
Fornax
Eridanus



The brilliant constellation Centaurus the Centaur lies in the thick depths of the southern Milky Way; scanning across it with binoculars reveals thousands of glittering stars. Omega Centauri, one of the group's brightest "stars," is actually the brightest globular star cluster in the sky and apears as a fuzzy patch of light in binoculars.

of 11th magnitude. Because this star is actually closer to us than the two brighter ones, it is called Proxima Centauri.

At magnitude −0.23, Agena (Beta Cen) — meaning "knee of the cenataur" — forms a spectacular wide pair with brilliant Alpha. Agena is a blue giant star, one of the hottest young stars found in the disk of our Galaxy. Only slightly fainter than Alpha, which lies 4.2 light-years off, Beta is some 490 light-years distant. It is truly the most brilliant of the pair. A line drawn from Alpha to Beta Centauri points toward Crux.

Other stars in Centaurus cover a wide range in types and brightnesses. One of the more unusual is Omega Centauri, not a star at all, though it appears so to the naked eye. Omega is actually a fourth-magnitude globular cluster: a huge halo of thousands of stars floating in the Milky Way's halo some 17,000 light-years away. Omega is among the most remote objects visible to the naked eye. With binoculars, you'll see it as larger and fuzzier than a star, and a small telescope easily reveals that it is a globe of stars.

East of Centaurus is the smaller, uniformly bright group of stars, Lupus the Wolf. Alpha Lupi is a variable bluish subgiant with a normal magnitude of 2.3. It lies 430 light-years away. Beta, slightly north of Alpha, is the same type of star shining at magnitude 2.7. Gamma, east of the Alpha/Beta area, is a bluish main sequence star of magnitude 2.8 lying 570 light-years away.

Several small constellations use the remaining Milky Way stars between Centaurus and Scorpius to the northeast. Circinus the Compass contains just one star brighter than fourth-magnitude — Alpha Circini, a third-magnitude blue-white double star. Norma the Carpenter's Square, a tiny box-shaped group of five stars, is faint enough to be completely overlooked in less than dark skies. Its brightest star is Gamma^2 Normae at magnitude 4.1. Triangulum Australis, the Southern Triangle, is small but contains some notable stars. Alpha Trianguli Australis is a magnitude 1.9 orange giant star 90 light-years from Earth. Beta, a second vertex, is a white subgiant star shining at magnitude 2.8 and lying some 42 light-years distant. Gamma, the third star comprising the Triangle, is a bluish main sequence star shining at magnitude 2.9 and lying 113 light-years away. Ara the Altar, another diminutive box-shaped group of stars, offers its brightest star Beta, at magnitude 2.8.

Opposite the glowing band of Milky Way from Centaurus is the large constellation Pavo the Peacock. Pavo contains one luminary, Alpha Pavonis, which sparkles at magnitude 1.9. It is a hot blue subgiant star some 293 light-years off. The two next-brightest stars are Beta (magnitude 3.5, blue-white giant) and Gamma (magnitude 4.3, white main sequence star). Nearby, the twisting form of Hydrus, the Small Water Snake, complements Hydra, the great Serpent/Monster of the north. It is a faint group whose brightest member — Beta Hydri — glows at magnitude 2.8.

The constellation Tucana the Toucan contains a number of goodies. Alpha Tucanae is a magnitude 2.9 orange giant star, while nearby Delta is a magnitude 4.8 bluish-white double star. On the other side of the constellation, Beta — a triple star — shines with the combined light of a magnitude 4.5 star. Near the southernmost reaches of Tucana are two special delights: 47 Tucanae — one of the sky's brightest globular clusters — and the Small Magellanic Cloud (SMC) — visible as a fuzzy patch several degrees in diameter. The Large Magellanic Cloud (LMC), found in the chain-like group known as Dorado the Goldfish, is over twice as large as the SMC and much brighter. Scanning the region with binoculars shows knots and clumps within the LMC, which is a satellite galaxy lying over 160,000 light-years away.

The southern sky is filled with varied constellations, stars, and unusual objects — and the many observers who travel south to see Comet Halley next year will have the chance to discover them. For those who live there, the far southern sky is an observational treat. Indeed, observers who have explored both hemispheres will often confirm — even rave — that the deep southern sky offers the most in beautiful star colors, patterns, and picturesque views.

— David J. Eicher

ASTRONOMY
Reviews

ASTRO
$39.95
Loquor Enterprises

ASTRO is a well-documented computer program on cassette for the Radio Shack TRS-80 Model 100 notebook computer. The program computes the positions for 180 of the brightest sky objects from any place on Earth at any time between 10,000 B.C. and 10,000 A.D. Additionally, it attempts to portray graphically their apparent sky positions.

By moving the cursor, the user can change the time, date, latitude, longitude, altitude, azimuth, and field of view. One nice feature is the "identification" command, which lets you move the cursor over any of the graphically-displayed sky objects to find the object's name and magnitude. Keying in an object's name will also command the computer to move the sky and display that object in the center of the screen.

Although the author claims that "stargazers can identify heavenly bodies by comparing the night sky to the display," you would need a great deal of imagination to do this. Because the program contains only 180 sky objects — all magnitude 3.5 or brighter — the displays are incomplete and confusing. Even a constellation with lots of bright stars, such as Orion, is almost impossible to recognize. Additionally, the computer's gnomonic projection distorts the sky, adding to the confusion.

Much of the problem is due to the Model 100's memory capacity (32K RAM when fully expanded); this limits the program significantly. ASTRO is written in BASIC and can be agonizingly slow. Rewritten in machine language, it would run faster and free more memory for additional objects. A final complaint: although I love my Model 100 dearly, its liquid crystal display has no built-in light for night use. Holding a flashlight to light the keyboard (as the author recommends) while you type in data is clumsy at best.

If you want an aid to learn the night sky, a good planisphere (a star finder with a rotating wheel) is far superior and much cheaper. But if you want a tight, well-written program as a key to understanding navigational planning and principles — or wish to see how the sky looked back when Thuban was the Pole Star — then this program may be just the one for you.
Bryan Shumaker.

ZX Spectrum Astronomy
Maurice Gavin
229 pages, softcover, 6.50
Sunshine Books (1984)

Subtitled "Discover the Heavens on Your Computer," this book details how to run simple ZX Spectrum computer programs for solar system and stellar astronomy. Included are time and the calendar, star tracker, Moon phases, Keplerian satellite orbits, a planetary ephemeris, galactic orbits, and the Sun's rotation about the galactic center.

Formation and Evolution of Galaxies and Large Structures in the Universe
Jean Audooze and
Jean Tran Thanh Van, eds.
453 pages, hardcover, $58
D. Reidel (1984)

The proceedings of a conference held by the NATO Advanced Study Institute, this book includes papers on the cosmology of the very early universe, clusters of galaxies, massive halos, early nucleosynthesis, and the structural, chemical, and dynamical evolution of galaxies.

Stephen Hawking's Universe
John Boslough
158 pages, hardcover, $12.95
William Morrow (1984)

Subtitled "An Introduction to the Most Remarkable Scientist of Our Time," this work describes the famed cosmologist from Cambridge University. Biographical information is included and the book concludes with "Is the End in Sight for Theoretical Physics?", a lecture by Hawking himself.

Observing the Universe
Nigel Henbest, ed.
288 pages, softcover, $8.95
Basil Blackwell (1984)

This book consists of a series of articles on astronomy from the English magazine *New Scientist*. Included in it are sections on the Big Bang (by Fred Hoyle), radio astronomy (by Nigel Calder and Martin Ryle), infrared research (by Michael Maunder), and the future of optical ground-based astronomy (by Nigel Henbest).

The Moment of Creation
James S. Trefil
234 pages, softcover, $6.95
MacMillan (1984)

This is a paperback edition of Trefil's 1983 book detailing cosmology from the Big Bang to the possible ultimate fate of the universe.

International Directory of Amateur Astronomical Societies
Andre Heck and Jean Manfroid, eds.
304 pages, paperback, no price given
Published by the editors (1984)
[Publishers' address: Dr. Andre Heck, Observatoire Astronomique de Strasbourg, 11 rue de l'Universite, 67000 Strasbourg, France]

This handy directory lists amateur astronomical groups around the world. It includes the organization's name, address, phone number, special activities, size of membership, and equipment available for members' use.

Asimov's New Guide to Science
Isaac Asimov
992 pages, hardcover, $29.95
Basic Books (1984)

This massive book for the general reader is actually two in one: it is subdivided into the physical sciences and the biological sciences. Asimov begins by asking "What is Science?" and then goes on to cover briefly a vast number of topics in every area of science. Chapters on astronomy include the distance scale of the universe, the solar system, the Earth, and the atmosphere.

The Creation of Matter
Harald Fritzsch
272 pages, hardcover, $19.95
Basic Books (1984)

The Creation of Matter details the physics of quarks, antimatter, quantum mechanics, the echo of the Big Bang, and other areas of modern cosmology for the general reader.

Astronomers of the Past
Donald Osterbrock and others
50 slides with explanatory booklet, $34.95
Astronomical Society of the Pacific (1984)

This set of black-and-white slides features familiar paintings and photographs of the great astronomers of the past — Barnard, Copernicus, Einstein, Galileo, Hale, Herschel, Hubble, Kepler, Lowell, Newton, Shapley, Slipher, Struve, and others. The booklet provides a short biography about each famous astronomer.

Patrick Moore's History of Astronomy
Patrick Moore
328 pages, hardcover, $19.95
Merrimack (1984)

This work is the fifth edition of Moore's 1961 book, originally titled *Astronomy*. Moore covers the general aspects of astronomy and highlights historical events including: the discoveries of Uranus, Neptune, and Pluto; the introduction of photography and spectroscopy into astronomy; the Royal Observatory and its history; and Lord Rosse's work at Birr Castle.

Our Solar System Calendar of 1985
John W. Hanses
1 sheet, tube-rolled, $5
Published by the author (1984)
[Publisher's address: P.O. Box 30005, Winona, MN 55987]

This calendar is a map of the solar system, intended to be cut out and glued onto a sheet of cardboard. The map, to scale as far out as Mars, shows the positions of the planets on various dates (daily for Mercury, monthly for Jupiter, every six months for Pluto). It is printed on heavy paper and includes a set of colored pins representing the Sun and planets, which you move around the map as the year rolls by (Saturn has a special cutout ring system you can attach to it). Since it's for 1985, the path of Comet Halley is also shown.

Our Place in Space
Guy Ottewell
10 slides, $8.95
Everything in the Universe (1984)

This slide set illustrates the solar system's position in relation to other stars, the Milky Way's location among neighboring galaxies, and the relationships between the ecliptic, galactic, and equatorial planes using three-dimensional line drawings.

Clusters and Groups of Galaxies
F. Mardirossian, G. Giuricin, and M. Mezzetti, eds.
659 pages, hardcover, $89.50
Reidel (1984)

Clusters and Groups of Galaxies is the proceedings volume from a professional conference held at Trieste, Italy, in September 1983. Among the topics covered are: the local supercluster, galaxy types in distant clusters, globular clusters and galaxy formation, superclusters, clustering in the southern hemisphere, and the Hubble diagram.

Time, Space, and Things, 2nd ed.
B.K. Ridley
182 pages, hardcover, $29.95;
paperback, $9.95
Cambridge University Press (1984)

"This book is an attempt to survey, in simple terms, what physics has to say about the fundamental structure of the universe." Avoiding mathematics almost entirely, Ridley nevertheless employs several physical concepts that will require close attention on the part of his readers.

Cecilia Payne-Gaposchkin
Katherine Haramundanis, ed.
269 pages, hardcover, $34.95
Cambridge University Press (1984)

This work contains mostly autobiographical writings edited by Payne-Gaposchkin's daughter, Katherine Haramundanis. Also included are recollections of the great Harvard astrophysicist from family, friends, and professional colleagues, and a collection of photographs showing Payne-Gaposchkin throughout her life.

Astronomy with Schmidt-Type Telescopes
Massimo Capaccioli, ed.
619 pages, hardcover, $84
D. Reidel (1984)

This book constitutes the proceedings of the 78th colloquium of the International Astronomical Union held in Asiago, Italy, during the summer of 1983. It outlines current astronomical research done with Schmidt telescopes — such as those at the European Southern Observatory, Palomar Observatory, and the United Kingdom Schmidt telescope — for various sky surveys, specialized work like surface photometry of large sky objects, studying superclustering of galaxies, and darkroom techniques for Schmidt films.

Total Eclipses of the Sun
J.B. Zirker
210 pages, hardcover, $22.50
Van Nostrand Reinhold (1984)

Written by the director of Sacramento Peak Observatory, *Total Eclipses of the Sun* explains for the interested lay reader the physics of eclipses: the Sun's chromosphere and corona, interplanetary dust, Earth's atmosphere, how eclipses support general relativity, etc. It also includes a section on the history of eclipse-watching and ideas for future experiments at total eclipses.

The New Race for Space
James Oberg
210 pages, softcover, $14.95
Stackpole Books (1984)

Oberg speculates on future space plans and past accomplishments from both the United States and the Soviet Union. He begins with a section on the commercialization of space and outlines methods for interplanetary space travel, potential Moon bases, and possible cooperation in joint projects between both superpowers.

Rings: Discoveries from Galileo to Voyager
James Elliot and Richard Kerr
200 pages, hardcover, $17.50
MIT Press (1985)

As of 1977, the field of planetary rings looked like a closed subject with all its major discoveries behind it. That notion vanished when Elliot and his co-workers discovered the rings of Uranus during an occultation-observing run in March that same year. Elliot provides a first-person narrative about the uranian discovery and describes the subsequent Voyager discoveries at Jupiter and Saturn. The last chapter looks toward the possibility of future ring discoveries.

High Energy Astrophysics and Cosmology
J. Yang, C. Zhu, eds.
529 pages, hardcover, $65
Gordon and Breach (1984)

This book records the proceedings of an international workshop on high energy astrophysics held at Nanjing, China in April 1982. Topics covered include pulsars, neutron stars, black holes, quasars, and the role of neutrinos in cosmology. The book is aimed at a professional astronomer readership.

ALCON '84
153 pages, paperback, $5.50
The Astronomical League (1984)

The 38th National Convention of the Astronomical League was held in Waukesha, Wisconsin in August 1984. This book contains the 17 papers given during the conference. Topics include advances in color astrophotography, the great martian dust storm of 1984, and observing Saturn with a small telescope.

The Case for Mars
Penelope J. Boston, ed.
320 pages, paperback, no price given
American Astronautical Society (1984)

Held in April-May 1981, the "Case for Mars" Conference gathered specialists from several fields to examine whether — and how — mankind might go about exploring, developing, and settling the Red Planet. A few of the chapters are somewhat technical, but the book is aimed at the interested lay reader.

Space: A Developing Role for Europe
L.J. Carter, P.M. Bainum, eds.
268 pages, paperback, no price given
American Astronautical Society (1984)

Looking at space exploration projects for the latter 1980s and the 1990s, 26 authors examine such ideas as telecommunications, Earth-resources monitoring, laser-tracking for studying tectonics, and far-ultraviolet astronomy. The papers assume an interested lay readership.

Rare Halos, Mirages, Anomalous Rainbows, and Related Electromagnetic Phenomena
William R. Corliss, compiler
238 pages, hardcover, $12.95
The Sourcebook Project (1984)

Corliss has compiled published accounts of unusual phenomena and classified them into eight categories according to type. The book includes place indexes, as well as original author, source, and subject indexes.

The price of looking it up just went *way down*!

WEBSTER'S
NEW UNIVERSAL
UNABRIDGED
DICTIONARY
SAVE $50

While most unabridged dictionaries sell for unabridged prices—$50, $60, $70—this 2,300-page Webster's costs only $19.95. Through a special arrangement with the publisher, we are now able to offer this $69.95 value at a 70%—or $50—markdown from the original price! Now, you can bring this widely respected reference into your home, office, or classroom. And just look at what the Webster's contains:

- Over 320,000 Words
- More than 3,000 Illustrations
- 19 Encyclopedic Supplements
- A Thumb-Indexed Format

This Standard Reference Has Over 320,000 Words

For more than 40 years, the Webster's comprehensiveness has made it *the* standard reference. With over 320,000 words and phrases, the *Webster's New Universal Unabridged Dictionary* continues that great tradition. The Webster's defines common and obscure words, words used in other centuries and words newly created in the sciences and the humanities.

More Than 3,000 Illustrations

The Webster's is strong on visuals, too. Finely detailed pen drawings appear through out the text, and there's a full section of color-plate illustrations of plants, animals, airplanes, ships, and more. These illustrations help make the Webster's a fun, visually exciting experience, especially for children.

GIANT PANDA (6ft. long)

19 Encyclopedic Supplements

Other dictionaries may contain a few supplements, but the Webster's has over *150 pages* of specialized information for every interest. Here are just *some* of the categories and features included.

- 9 Large, Full-Color Maps
- Dictionaries of Place Names and Geographical Features
- A Dictionary of Biography
- Dictionaries of Names from the Bible, Myths, and Fiction
- A Dictionary of Commonly Used Abbreviations
- Forms of Addresses
- The Basics of Practical Math
- Commonly Used Financial and Commercial Terms
- A Dictionary of Foreign Words and Phrases

A Tradition of Quality

Concise, correct, complete definitions have been the hallmark of the Webster's since the distinguished philologist Noah Webster published the first edition in 1806. The Webster tradition of quality also extends to its format and organization. The pages are thumb-indexed for handy reference. While other large dictionaries use eye-straining type, the Webster's features good-sized print, with defined words standing out clearly in boldface. To make reading easier still, each definition is listed on a separate line or set of lines.

We Repeat: $19.95 Is An Unbeatable Value

An *unabridged* dictionary that sells for $19.95 is a rare find, especially when the dictionary bears a famous name like Webster's. And, as with anything you buy by mail from us, our **30-day money-back guarantee** means that if you decide to return this dictionary within 30 days, we will refund your money *in full*.

SINCE 1873
Barnes & Noble
BOOKSTORES
126 FIFTH AVE., DEPT. W219, N.Y., N.Y. 10011

1189398. Please rush me____copies of the Webster's New Universal Unabridged Dictionary at your special sale price of $19.95 (plus $3.00 shipping & insurance per volume.) N.Y. and N.J. residents: Please add sales tax.

Name ____________________
Address ____________________
City ____________________
State____________________Zip
Offer good only in the continental U.S.A

FOR FASTEST SERVICE
Credit Card Customers Call
Toll Free-24 hours-7 days a week
1-800-824-6200
EXT. 219

✓ Check One
☐ Payment enclosed
☐ I prefer to charge this purchase to:
☐ AMERICAN EXPRESS Card ☐ VISA ☐ Master Card

Account# __________ Exp.
Signature __________
© 1985 Barnes & Noble Bookstores, Inc.

Eye on the Sky

Venus' Dramatic Exit

by
Fred Schaaf

March 17
(looking SE 45 minutes before sunrise)
Jupiter
Moon

The Moon, Jupiter, and Saturn hover over Sheep Mountain and the Buffalo Bill Reservoir near Cody, Wyoming. Photo by Mack Frost; 35mm f/5.6 lens, 45-second exposure, ISO 400 film.

The Wanderers

This month **Venus** begins a dramatic exit from the evening sky, departing in early April, when it also nears inferior conjunction. Observers in northern temperate lands will still be able to see the planet after sunset, because of the steep angle at which the ecliptic meets the western horizon. More unusual, however, is how remarkably far north of the ecliptic (and therefore the Sun) Venus is at this inferior conjunction.

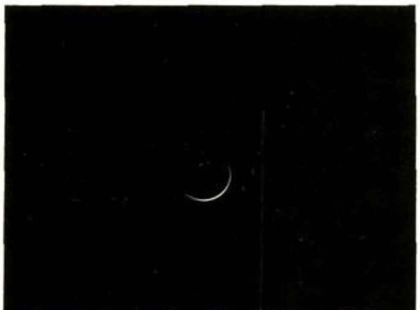
Venus will come so close to us that its distance above the plane of Earth's orbit translates into a separation of many degrees north of the solar disk. When inferior conjunction takes place on April 4, Venus will be 7.7° north of the Sun's center. For the northern hemisphere, this is Venus' best separation at inferior conjunction during the entire eight-year cycle of Venus' appearances.

During March, Venus sinks from an altitude at the time of sunset of 40° to less than 5°. Our sister planet has come around the last bend of its orbit and will appear to be travelling perpendicularly to our line of sight toward the Sun. Venus' rapid apparent motion is also due to its proximity to Earth. Its orbital speed stays the same, but seems greater because Venus passes only 30 million miles away. Following Venus against the background stars, we see that on March 13 Venus begins retrograde motion for the first time in about a year and a half.

This month provides a favorable evening apparition of **Mercury**. Start looking for this zero-magnitude planet low in the west during the second week of March. After passing perihelion (0.31 AU) on the 11th, Mercury reaches a greatest eastern elongation of 18.5° on the 17th — almost the smallest elongation possible, but still a good apparition because of the steeply-inclined ecliptic.

For information on viewing the Moon, planets, and deep-sky objects with telescopes, see **The Backyard Astronomer**.

Mercury should be easy to find until about the 24th, even though it fades by almost a full magnitude during the third week of the month. In North America on the evening of the 22nd, Venus lies 5° 17′ north of Mercury. An added attraction both this night and the next is the presence of a young Moon, which forms lovely arrangements with both planets.



Approximate the view of Venus' thin crescent in 20x binoculars by holding this page at arm's length. The phase is shown for mid-month.

On the 24th, just two days after the Mercury-Venus conjunction, Mercury begins retrograding in pursuit of Venus. Mercury's brightness now fades to second-magnitude and the planet becomes lost in the glow of twilight. During their March 22 conjunction, the pair of planets is still about 18° from the Sun; thereafter, they begin to lose a degree or more of elongation each day.

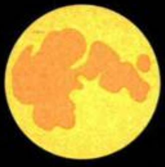
Why is Mercury fading? Not because of distance — it is, in fact, at its closest to us near inferior conjunction. However, during the last third of March, Mercury becomes a slender sunlit crescent. This occurs even more spectacularly in the splendidly-bright and close Venus. Although Venus shines at around magnitude −4.4 as March begins and is imperceptibly dimmer at mid-month, it then loses a half magnitude and about 15 degrees of altitude — all within 10 days.

Before Venus dips too far below the horizon, view it with binoculars. Even 2x or 3x field glasses, if mounted on a tripod or held steady, should show you Venus' tiny crescent, wire-thin and measuring about an arc-minute from cusp to cusp.

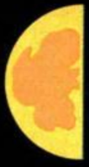
Mars shines at magnitude 1.4 and is only a few degrees from Venus. Around mid-month these planets lie within 10° of each other, although afterward their separation increases rapidly.

Late in the evenings, **Saturn** springs up in the southeast. During March, this planet imitates a star by remaining almost

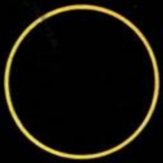
March's Night Sky



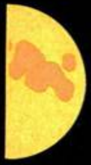
Full Moon
March 6
9:13 p.m. EST



Last Quarter
March 13
12:34 p.m. EST



New Moon
March 21
6:59 a.m. EST



First Quarter
March 29
11:11 a.m. EST

1st Tonight or tomorrow night, Mercury will begin appearing very low in the western sky after sunset. Look for a ruddy "star" about as bright as Sirius in Canis Major, but somewhat hidden in the twilight. It will remain visible most of March.

8th The Moon is closest to Earth at 2:50 a.m. EST: 223,292 miles.

11th Saturn is overtaken by a waning gibbous Moon in the morning sky. The Moon passes 3° south of the planet.

12th Venus is stationary in right ascension.

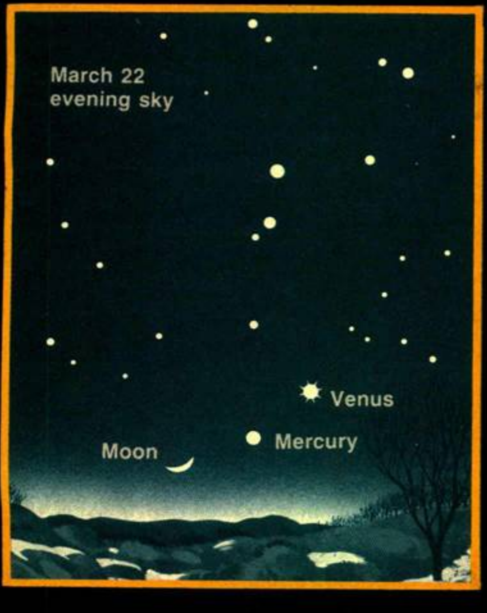
17th In the predawn sky, a waning crescent Moon passes 5° south of Jupiter (see diagram, p. 42). In the evening sky, Mercury is at greatest eastern elongation from the Sun. Now at its greatest height and best visibility, it will begin to sink toward the western horizon each evening after today. By the end of March, Mercury will be too close to the Sun to be seen. After passing between the Earth and Sun on April 3rd, it will reappear in the morning sky around mid-April.

20th Spring begins in the northern hemisphere at 11:14 a.m. EST.

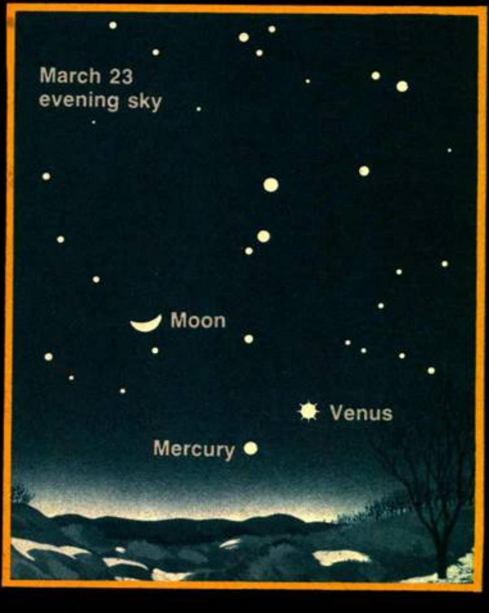
22nd Tonight and tomorrow night, the Moon, Venus, and Mercury will form a pretty grouping in the evening sky just after sunset (see diagrams below).

23rd The Moon is farthest from Earth at 10:05 a.m. EST: 252,458 miles.

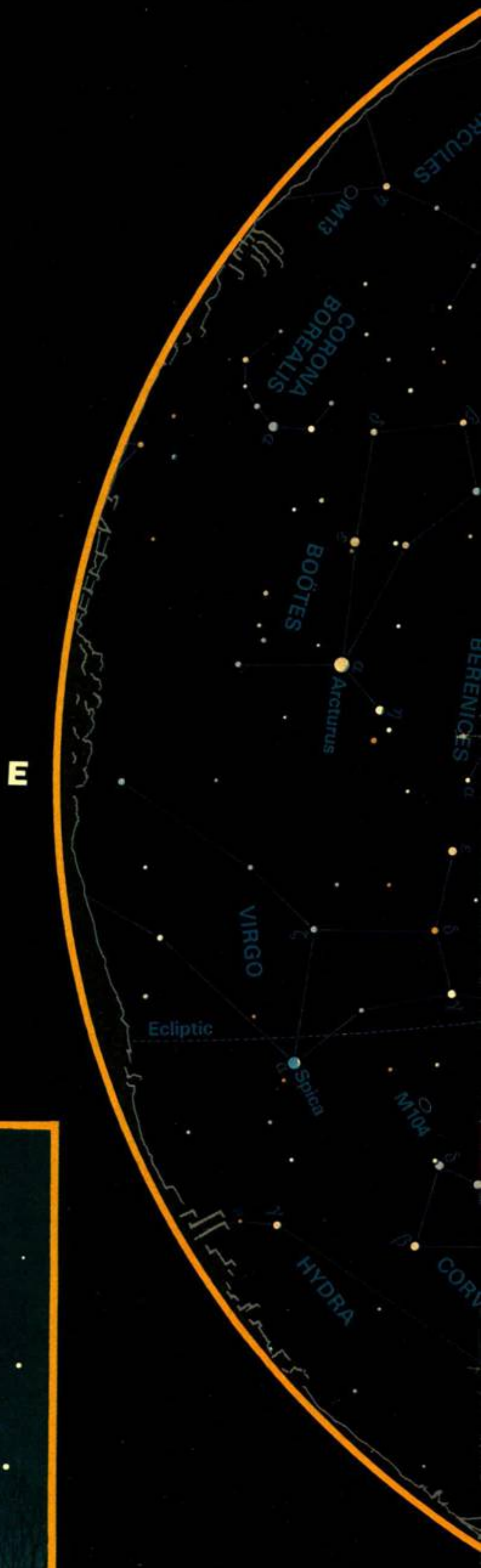
24th Mercury is stationary in right ascension; the Moon passes 1.4° south of Mars in the evening sky.

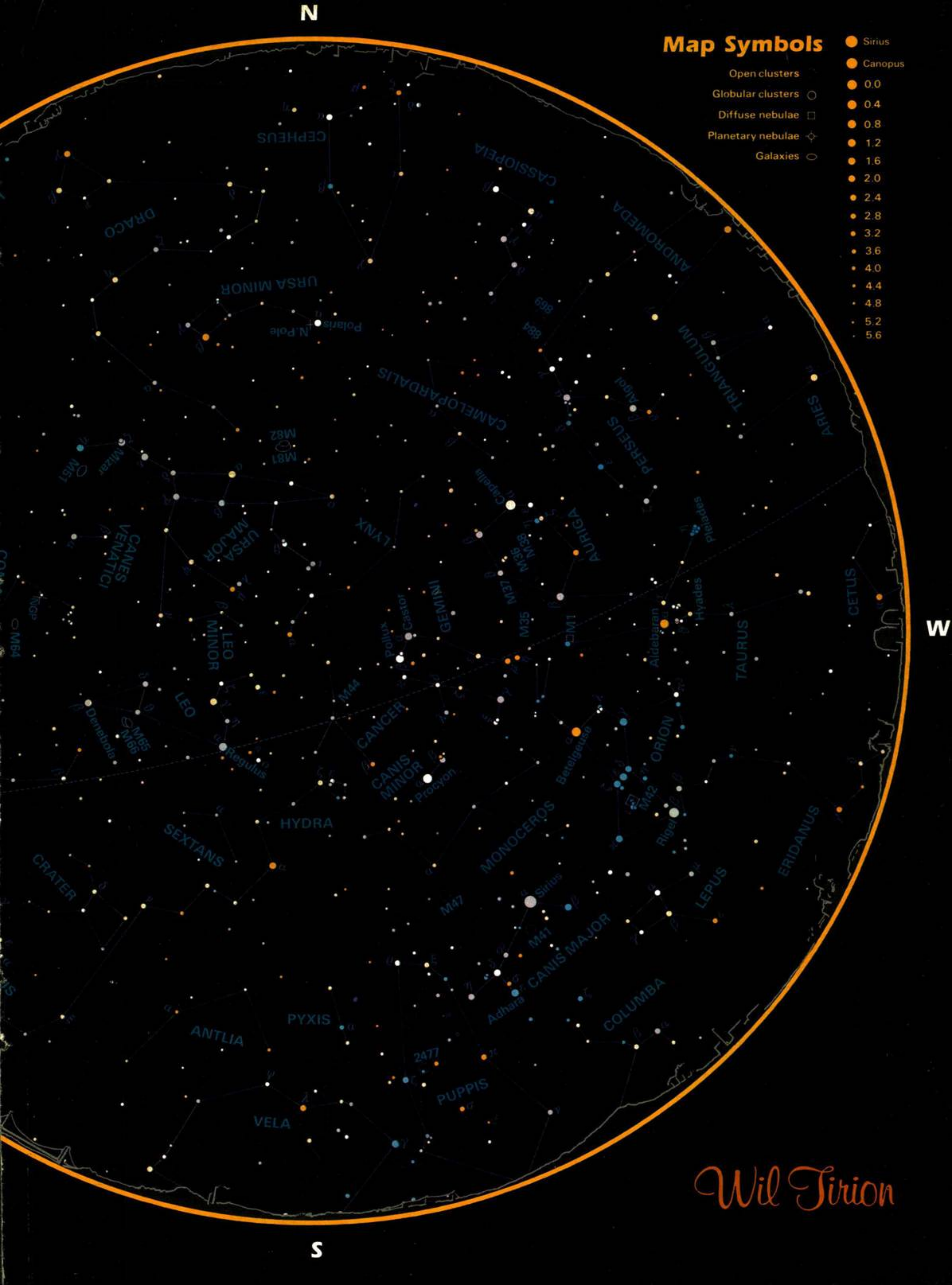


March 22
evening sky

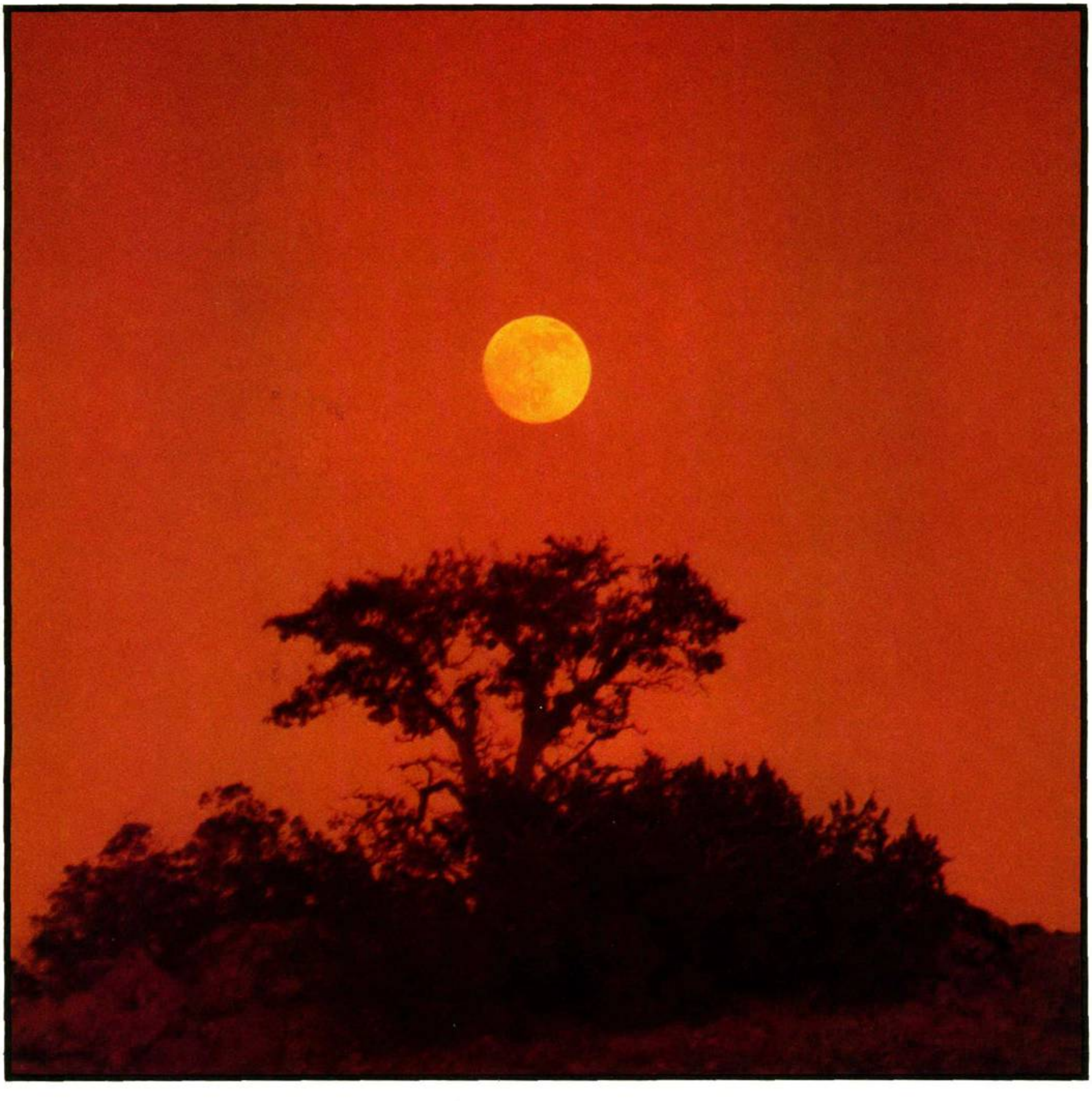


March 23
evening sky




N
Map Symbols
Sirius
Canopus
Open clusters
Globular clusters
Diffuse nebulae
Planetary nebulae
Galaxies
0.0
0.4
0.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
4.0
4.4
4.8
5.2
5.6
CEPHEUS
CASSIOPEIA
DRACO
ANDROMEDA
URSA MINOR
869
884
Polaris
N.Pole
TRIANGULUM
CAMELOPARDALIS
Algol
ARIES
PERSEUS
M82
M81
M51
Mizar
Capella
Pleiades
LYNX
CANES VENATICI
URSA MAJOR
AURIGA
M36
M38
M37
GEMINI
Castor
Pollux
M35
M1
Aldebaran
Hyades
CETUS
W
TAURUS
LEO MINOR
M3
M64
M44
CANCER
LEO
Denebola
M65
M66
Regulus
ORION
CANIS MINOR
Procyon
Betelgeuse
M42
Rigel
HYDRA
SEXTANS
MONOCEROS
ERIDANUS
CRATER
LEPUS
Sirius
M47
M41
CANIS MAJOR
COLUMBA
Adhara
PYXIS
ANTLIA
2477
PUPPIS
VELA
S

Wil Tirion



motionless in eastern Libra the entire month. Saturn begins retrograde motion on March 7th.

Solitary **Jupiter** now has about a quarter of the zodiac to itself. This −2 magnitude planet rises in the early morning hours. At 19h UT on the 31st, Jupiter shines only 4 arc-minutes north of the magnitude 5.9 star 19 Capricorni (a star similar in brightness to Jupiter's Galilean satellites). What scene of star, planet, and moons awaits you and a pair of binoculars?

The Starry Sky

Another winter is drawing to a close. What observer can watch Orion, the Pleiades, or Sirius sinking into the west without regret? These celestial beauties are not gone yet, however.

Gemini the Twins lies far enough north to remain easily visible past mid-spring to viewers around 40° north latitude. In fact, the two brightest stars of Gemini are in the northeastern part of the constellation and remain visible low in the west after sunset even in June. The two are **Castor** (Alpha [α] Gem) and **Pollux** (Beta [β] Gem).

Pollux does not belong to that class of first-magnitude stars — Regulus, Spica, Antares, and Aldebaran — which are occasionally occulted by the Moon. During some years, however, close conjunctions between the Moon and Pollux also occur. After visiting Pollux and Castor, the Moon moves on to **Cancer** the Crab. There it frequently passes near the famous Beehive Star Cluster, **Messier 44**. In binoculars, this naked-eye patch of fuzzy light is a fine honeycomb of stars. Cancer itself offers only a faint pattern, so if you observe in light-polluted skies, look about halfway between Pollux and Regulus to find Cancer and the Beehive.

Although not much brighter than Cancer, the head of **Hydra** the Sea Serpent is compact and distinctive. As spring opens, Cancer and Hydra are on the meridian at mid-evening, although Hydra's tail is still rising. We will look more at both of these constellations next month.

Shortly after nightfall, you may wish to complete your winter viewing by exploring the southern reaches of the winter Milky Way. If your skies are dark, down near the southern horizon, southeast of Sirius, you will find some bright patches representing the rich open clusters of **Puppis**. (Binoculars will help

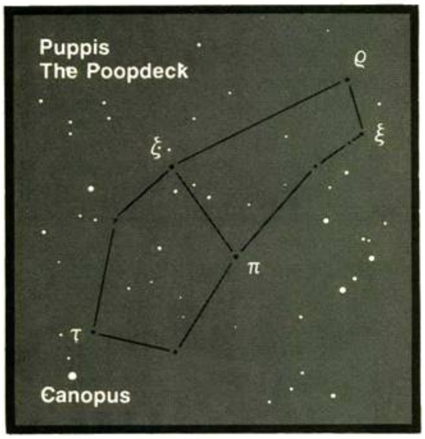
The 13-day old Moon rises over California's Mojave Desert. Photo by Chris Quinnert; 250mm f/4.6 lens, ½-second exposure.

here.) Puppis is the poop deck of what was once the constellation Argo, the ship of the Argonauts. Within this constellation is the second-magnitude star **Zeta** (ζ) **Puppis**, also called Naos, which is the brightest of a class of hot suns called Wolf-Rayet stars. Naos is one of the very bluest stars in the sky.

Winter is just passing, but already Arcturus in Bootes is rising in the early evening sky. Leo and the Big Dipper are also climbing in the east — Spring cannot be far behind.

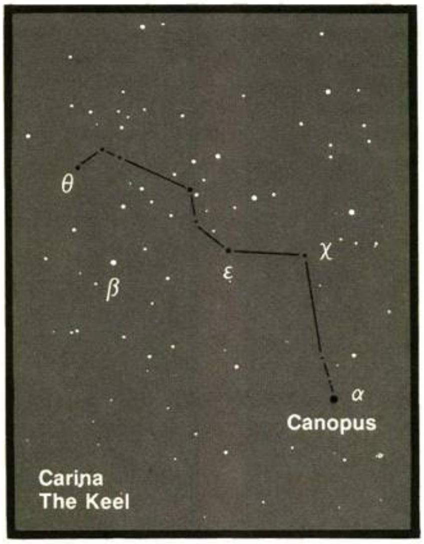
Skylore

There is no constellation called Jason, but his ship the Argo still sails the celestial seas. Argo plays a key role in Jason's tale — a story of adventure and tragedy.



Mythology's mightiest heroes, in their quest for the Golden Fleece, needed a ship larger than any ever built. For this task, Argus of Thespia supervised the construction of an enormous vessel, complete with 50 oars. Workers brought seasoned timber from nearby Mount Pelion. Athena herself brought a board and placed it into the new ship's prow; cut from the sacred oak of Zeus, it could magically speak prophecies. The ship was called Argo after its builder whose name means bright.

Among the Argonauts were mighty Hercules, the twins Castor and Pollux, the great musician Orpheus, and the swift and powerful maiden Atalanta. The Argo set sail a generation before the Trojan War, perhaps about 1300 B.C. The epic poets Homer and Hesiod both refer to it. However, they probably knew a much different tale of the Argonaut mission than our version, which originated largely from Apollonius of Rhodes in the 3rd century B.C. During Jason's era, the Argonauts were the most powerful and revered of all men. Surely no ship ever faced more perils than the Argo. After saving Phineus from hideous birds called Harpies, the Argonauts had to make passage through the dreaded Symplegades — the Clashing Rocks. According to legend, these great rocks guard the narrow entrance to the Bosphorus by slamming thunderously together, crushing anything in their way. Using Phineus' advice, the Argonauts released a dove to see if the bird could fly through the entrance before the rocks came crashing together.



They watched breathlessly as the dove soared through the sea's blue mist. When the thunder died down and the rocks parted, they saw that the dove had escaped. But just barely: her tail feathers were clipped because the race was so close. As the rocks moved apart, Jason urged his men to row their hardest and Orpheus inspired them to their greatest effort with his music. The rocks closed in, looming on both sides through the mist. With a last desperate surge, the Argonauts rowed and the ship sped forward through the clashing rocks; the ship reeled, but only its stern was destroyed. Argo, like the dove, had barely made the passage. In tribute to the crew's courage and strength, the gods brought the giant rocks lurching to a halt and they never again denied passage to sailors.

Eventually the Argo reached Colchis, where the Golden Fleece was held under the control of King Aeetes. The quest would have been lost, but Aphrodite had her son Cupid shoot an arrow into Aeetes' daughter Medea, causing her to fall in love with Jason. Aeetes would still not relinquish the Fleece, but Medea took Jason to it.

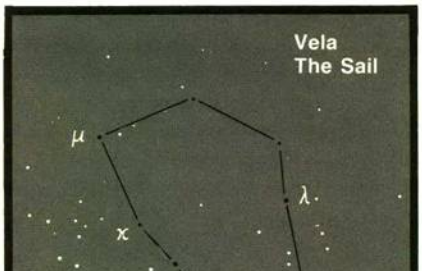
The Golden Fleece was protected by a fierce dragon, who was larger than the Argo and never slept. Once again Medea's powerful sorcery prevailed: she sang incantations to calm the dragon, then cast drops of sleeping potion into the monster's eyes. Jason carefully removed the Fleece and the two of them fled.

According to many accounts, Jason and Medea performed an act of incredible treachery to escape the fleets that blocked Argo's route in the Black Sea. Medea lied to her brother, and either she or Jason murdered him — perhaps by dismemberment — and threw the pieces into the sea to delay Aeetes' ships, which stopped to gather them. Having committed murder, Jason and Medea had to leave the ship and go to the island of Circe to cleanse themselves of the bloody crime.

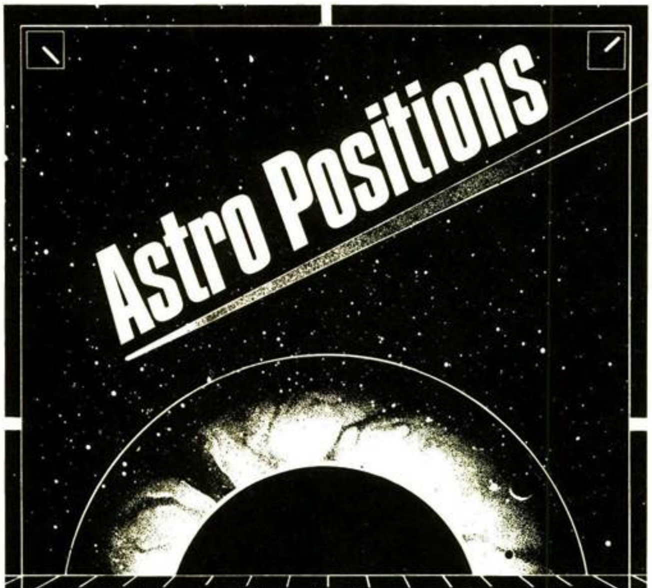
The adventures of the Argo on the way home were even more varied and spectacular. The Argonauts passed the island of the Sirens — saved only by Orpheus' compelling song. With help from the gods, they escaped the monster Scylla and the whirlpool Charybdis. They destroyed the giant bronze man Talos through the sorcery of Medea. And again the song of Orpheus saved them — this time from a great storm: Argo was almost overwhelmed until the music of the minstrel calmed the wind and waves.

Argo finally returned to Greece with the Fleece. But like so many glorious adventures, the aftermath was anything but happy. Medea's revenge on Jason's enemies increased, but worse was Jason's betrayal of this woman he had promised to marry, apparently for the sake of ambition. Medea married the King of Corinth and was last seen flying off in a chariot drawn by winged dragons on her way to immortality.

Jason had a dark fate. In old age, after years of beggarly wandering, he returned to Corinth where the Argo was docked. He sat by the ship, thinking of his glorious days and how he had wasted them. Jason decided to hang himself from the bow of the ship, but before he could, the bow collapsed and crashed down, killing him.



Some say this was the part of the ship where Medea's brother was murdered, which may explain why Poseidon could only lift part of the ship into the sky to be honored among the stars. Whatever the reason, Argo sails the heavens backwards without a bow — its stern leading the rest of the ship on its nightly westward voyage.



Combines positional astronomy for the student and hobbyist with charting for the astrology buff. Calculate position of sun, moon, planets and stars for any calendar date from any location using topocentric, geocentric or heliocentric data. Guidebook on Astronomy included with field projects.

Commodore 64 Dealer Availability Call (203) 389-8383 **Disk $49.95**

MICRO**TECHNIC**
SOLUTIONS
P.O. BOX 2940, NEW HAVEN, CONN. 06515

REVISED, EXPANDED SECOND EDITION

HOW TO BUILD A DOBSONIAN TELESCOPE

Reprints from Telescope Making and **ASTRONOMY** Magazines

Would you like to build your own 10″ telescope? Well, you can — and for a lot less time and money than you thought. Our 52-page booklet gives you complete instructions on how to build a 10″ Dobsonian — plus helpful diagrams and plenty of informative articles and photographs on 12″, 16″ and 20″ scopes. This new and expanded edition also tells you how to calculate bearing size, how to use a Poncet platform for deep-sky astrophotography, and how to use setting circles and your pocket computer to find your favorite celestial objects.

This is a complete Dobsonian manual — covering each step from choosing materials to aiming your new scope.

ONLY
$4.95

To order, use the AstroMedia order form bound into this magazine, or send to AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

How to Build a
DOBSONIAN
TELESCOPE
Second Edition
Reprints from TELESCOPE MAKING magazine

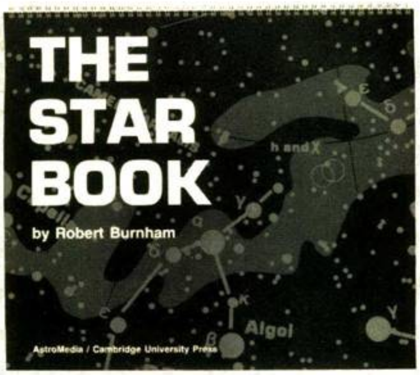
Celestron SP-C8

TELESCOPES
ACCESSORIES
ALL MAJOR BRANDS
LOW, LOW PRICES
FAST, HONEST SERVICE
FREE
DISCOUNT
PRICE
LIST

CALIF. TELESCOPE CO.
P.O. Box 1338, Burbank, California 91507
Send Business-sized S.A.S.E. for FREE Discount Price List
Visa/Mastercard/Check/M.O. U.S. Sales Only
Orders Only
10a-4p Pac. Time,
Monday-Friday : **(818)505-8424**

Meade 2044, 2080, 2120

Order Your Copy of



THE STAR BOOK
by Robert Burnham
AstroMedia / Cambridge University Press

Today!

Now in its second big printing, **THE STAR BOOK** is the surefire way for anyone to learn the constellations. Clear and informative maps, coupled with fascinating sky lore, add up to a delightful work that has satisfied thousands of users!

THE STAR BOOK is designed to give years of useful service. The maps, deep blue and black with white stars, are both handsome and practical. Constellation names and outlines shown in pale gray; all major stars named; naked-eye and binocular galaxies, clusters, and nebulae are identified.

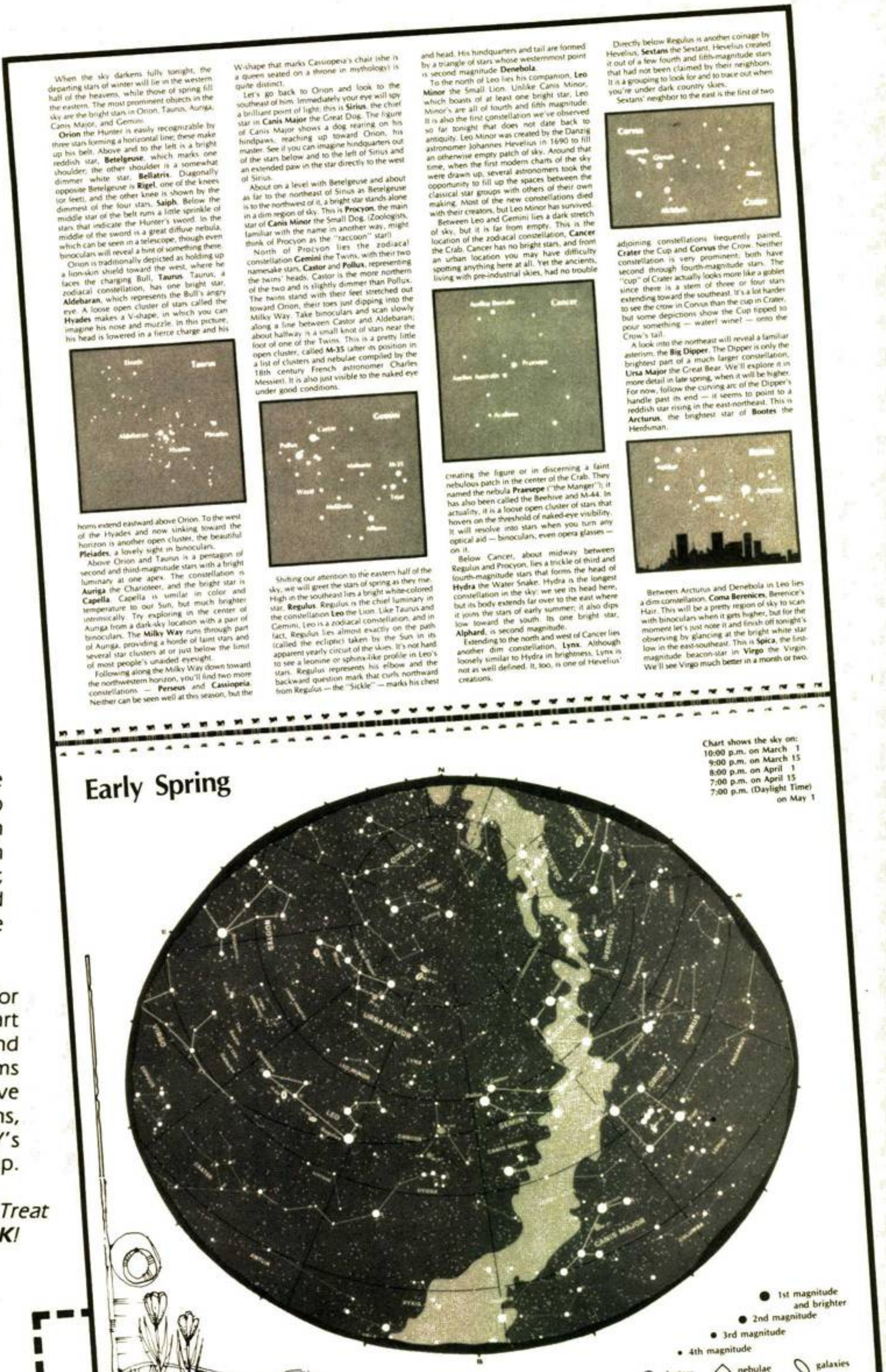
Eight maps provide enough overlap for observing at any time of the year. Start with the prominent star patterns and progress by easy steps to the faint realms of the sky. A concise and informative description of the stars, the constellations, their lore and legends by ASTRONOMY's Robert Burnham accompanies each map.

*Tired of dog-earing your magazines? Treat yourself to a copy of **THE STAR BOOK**!*

$6.95

postage included

- **8 charts cover all seasons**
- **shows all constellations visible from mid-northern latitudes**
- **easy to use at night**
- **folds back for convenient observing**
- **printed in two colors on thick cardstock**
- **overcoated with a durable water-resistant varnish**
- **heavy-duty spiral binding**
- **designed to give years and years of service**
- **perfect for family outings**
- **measures 10" x 11¼"**



When the sky darkens fully tonight, the departing stars of winter will lie in the western half of the heavens, while those of spring fill the eastern. The most prominent objects in the sky are the bright stars in Orion, Taurus, Auriga, Canis Major, and Gemini.

Orion the Hunter is easily recognizable by three stars forming a horizontal line; these make up his belt. Above and to the left is a bright reddish star, **Betelgeuse**, which marks one shoulder; the other shoulder is a somewhat dimmer white star, **Bellatrix**. Diagonally opposite Betelgeuse is **Rigel**, one of the knees (or feet), and the other knee is shown by the dimmest of the four stars, **Saiph**. Below the middle star of the belt runs a little sprinkle of stars that indicate the Hunter's sword. In the middle of the sword is a great diffuse nebula, which can be seen in a telescope, though even binoculars will reveal a hint of something there.

Orion is traditionally depicted as holding up a lion-skin shield toward the west, where he faces the charging Bull, **Taurus**. Taurus, a zodiacal constellation, has one bright star, **Aldebaran**, which represents the Bull's angry eye. A loose open cluster of stars called the **Hyades** makes a V-shape, in which you can imagine his nose and muzzle. In this picture, his head is lowered in a fierce charge and his horns extend eastward above Orion. To the west of the Hyades and now sinking toward the horizon is another open cluster, the beautiful **Pleiades**, a lovely sight in binoculars.

Above Orion and Taurus is a pentagon of second and third-magnitude stars with a bright luminary at one apex. The constellation is **Auriga** the Charioteer, and the bright star is **Capella**. Capella is similar in color and temperature to our Sun, but much brighter intrinsically. Try exploring in the center of Auriga from a dark-sky location with a pair of binoculars. The **Milky Way** runs through part of Auriga, providing a horde of faint stars and several star clusters at or just below the limit of most people's unaided eyesight.

Following along the Milky Way down toward the northwestern horizon, you'll find two more constellations — **Perseus** and **Cassiopeia**. Neither can be seen well at this season, but the W-shape that marks Cassiopeia's chair (she is a queen seated on a throne in mythology) is quite distinct.

Let's go back to Orion and look to the southeast of him. Immediately your eye will spy a brilliant point of light; this is **Sirius**, the chief star in **Canis Major** the Great Dog. The figure of Canis Major shows a dog rearing on his hindpaws, reaching up toward Orion, his master. See if you can imagine hindquarters out of the stars below and to the left of Sirius and an extended paw in the star directly to the west of Sirius.

About on a level with Betelgeuse and about as far to the northeast of Sirius as Betelgeuse is to the northwest of it, a bright star stands alone in a dim region of sky. This is **Procyon**, the main star of **Canis Minor** the Small Dog. (Zoologists, familiar with the name in another way, might think of Procyon as the "raccoon" star!)

North of Procyon lies the zodiacal constellation **Gemini** the Twins, with their two namesake stars, **Castor** and **Pollux**, representing the twins' heads. Castor is the more northern of the two and is slightly dimmer than Pollux. The twins stand with their feet stretched out toward Orion, their toes just dipping into the Milky Way. Take binoculars and scan slowly along a line between Castor and Aldebaran; about halfway is a small knot of stars near the foot of one of the Twins. This is a pretty little open cluster, called **M-35** (after its position in a list of clusters and nebulae compiled by the 18th century French astronomer Charles Messier). It is also just visible to the naked eye under good conditions.

Shifting our attention to the eastern half of the sky, we will greet the stars of spring as they rise. High in the southeast lies a bright white-colored star, **Regulus**. Regulus is the chief luminary in the constellation **Leo** the Lion. Like Taurus and Gemini, Leo is a zodiacal constellation, and in fact, Regulus lies almost exactly on the path (called the ecliptic) taken by the Sun in its apparent yearly circuit of the skies. It's not hard to see a leonine or sphinx-like profile in Leo's stars. Regulus represents his elbow and the backward question mark that curls northward from Regulus — the "Sickle" — marks his chest and head. His hindquarters and tail are formed by a triangle of stars whose westernmost point is second magnitude **Denebola**.

To the north of Leo lies his companion, **Leo Minor** the Small Lion. Unlike Canis Minor, which boasts of at least one bright star, Leo Minor's are all of fourth and fifth magnitude. It is also the first constellation we've observed so far tonight that does not date back to antiquity. Leo Minor was created by the Danzig astronomer Johannes Hevelius in 1690 to fill an otherwise empty patch of sky. Around that time, when the first modern charts of the sky were drawn up, several astronomers took the opportunity to fill up the spaces between the classical star groups with others of their own making. Most of the new constellations died with their creators, but Leo Minor has survived.

Between Leo and Gemini lies a dark stretch of sky, but it is far from empty. This is the location of the zodiacal constellation, **Cancer** the Crab. Cancer has no bright stars, and from an urban location you may have difficulty spotting anything here at all. Yet the ancients, living with pre-industrial skies, had no trouble creating the figure or in discerning a faint nebulous patch in the center of the Crab. They named the nebula **Praesepe** ("the Manger"); it has also been called the Beehive and M-44. In actuality, it is a loose open cluster of stars that hovers on the threshold of naked-eye visibility. It will resolve into stars when you turn any optical aid — binoculars, even opera glasses — on it.

Below Cancer, about midway between Regulus and Procyon, lies a trickle of third and fourth-magnitude stars that forms the head of **Hydra** the Water Snake. Hydra is the longest constellation in the sky; we see its head here, but its body extends far over to the east where it joins the stars of early summer; it also dips low toward the south. Its one bright star, **Alphard**, is second magnitude.

Extending to the north and west of Cancer lies another dim constellation, **Lynx**. Although loosely similar to Hydra in brightness, Lynx is not as well defined. It, too, is one of Hevelius' creations.

Directly below Regulus is another coinage by Hevelius, **Sextans** the Sextant. Hevelius created it out of a few fourth and fifth-magnitude stars that had not been claimed by their neighbors. It is a grouping to look for and to trace out when you're under dark country skies.

Sextans' neighbor to the east is the first of two adjoining constellations frequently paired, **Crater** the Cup and **Corvus** the Crow. Neither constellation is very prominent; both have second through fourth-magnitude stars. The "cup" of Crater actually looks more like a goblet since there is a stem of three or four stars extending toward the southeast. It's a lot harder to see the crow in Corvus than the cup in Crater, but some depictions show the Cup tipped to pour something — water? wine? — onto the Crow's tail.

A look into the northeast will reveal a familiar asterism, the **Big Dipper**. The Dipper is only the brightest part of a much larger constellation, **Ursa Major** the Great Bear. We'll explore it in more detail in late spring, when it will be higher. For now, follow the curving arc of the Dipper's handle past its end — it seems to point to a reddish star rising in the east-northeast. This is **Arcturus**, the brightest star of **Bootes** the Herdsman.

Between Arcturus and Denebola in Leo lies a dim constellation, **Coma Berenices**, Berenice's Hair. This will be a pretty region of sky to scan with binoculars when it gets higher, but for the moment let's just note it and finish off tonight's observing by glancing at the bright white star low in the east-southeast. This is **Spica**, the first-magnitude beacon-star in **Virgo** the Virgin. We'll see Virgo much better in a month or two.

Early Spring

Chart shows the sky on:
10:00 p.m. on March 1
9:00 p.m. on March 15
8:00 p.m. on April 1
7:00 p.m. on April 15
7:00 p.m. (Daylight Time) on May 1

● 1st magnitude and brighter
● 2nd magnitude
● 3rd magnitude
• 4th magnitude
○ clusters ◇ nebulae ⬯ galaxies

Yes, send me________copy(ies) of **THE STAR BOOK** at only **$6.95** each.

Name______________________________

Address______________________________

City________________ State________ Zip________

Send this coupon or a copy to AstroMedia Order Dept., P. O. Box 92788, Milwaukee, WI 53202 — or use the handy AstroMedia order form bound into this magazine.

Meade & Celestron
LUMICON Carries a full line of telescopes & accessories. Fast Delivery, competitive prices. Both Catalogues $3.

LUMICON FOR HIGH PERFORMANCE

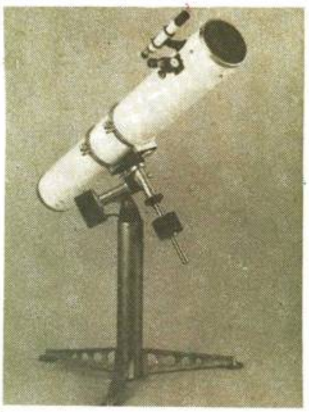
ASTROPHOTO OF THE MONTH

Edge-on galaxy NGC 4565 in Coma Berenices. This superb 10th magnitude galaxy is seen well in 8" and larger telescopes. Photo by David Healy using hypered 2415 film and a LUMICON Giant EASY-GUIDER. 1 hour exposure, C-14 at f/6.

Meade TELESCOPES AT LUMICON

Meade Model 2080 8"f/10 Schmidt-Cassegrain Telescope with wedge & tripod. The **Meade 2080** is the best value today in 8" Schmidt-Cassegrain telescopes. It includes fork mount, 6X30mm finderscope, 80X and 220X eyepieces, wedge & tripod. The **Meade 2080LX2** has the high precision LX drive system for photography, 8X50mm *right-angle* view-finder, special coatings, 20mm (100x) Erfle and 7mm (286x) orthoscopic research grade eyepieces, wedge, tripod, and no-tool know set. Both telescopes have a lifetime warrenty. The dew shield and accessory tray are highly recommended. Shipped f.o.b. Livermore

Model 2080 with wedge & tripod **$1095**
Model 2080LX2 with wedge & tripod . . **$1279**
NEW! Meade 2080LX3 with built-in quartz drive corrector, wedge & tripod. **$1595**
Dew Shield & accessory tray ($100 list) . **$69**
Enhanced mirror coatings group adds 16-18% trans., highly recommended ... **$99**
Model 46L dual-axis drive corrector & electric declination for photography **$288**
LUMICON Cassegrain EASY-GUIDER and Rich-Field viewer combination . . **$add $198**



Meade Model 628 6"f/8 Newtonian Telescope

Meade 6" & 8" Newtonian Telescopes offer the best value today for serious amateurs. The **Model 628** yields the best Lunar/planetary viewing. The **Model 826** collects 78% more light and is thus better for deep-sky viewing and photography. These telescopes include a motor drive, 6X30mm view finder, 1¼" rack & pinion focuser, 25mm (48x) and 9mm (135mm) eyepieces, setting circles, and a sturdy equatorial mount with pier and legs. Shipped f.o.b. Livermore CA.

Model 628, 6"f/8 with motor drive **$595**
Model 645, 6"f/5 Rich-Field Telescope . **$625**
Model 826, 8"f/6 with motor drive **$699**
Substitute #680 2" focuser .... **add $39**
Substitute 8X50mm view finder .... **add $45**
Dust covers (2) 6" .... **$15** 8" **$20**
Accessory shelf for eyepieces etc **$28**
Model 47M dual-axis drive corrector and electric declination for photography ($360 list) **$298**
LUMICON 2" EASY-GUIDER for perfect astrophotos (requires #680 focuser) .... **add $139**
1¼" LUMICON UHC Filter, prem. . . **add $89**

LUMICON® FILTERS

STOP LIGHT POLLUTION

The **LUMICON DEEP-SKY Filter**™ improves both visual and photographic contrast on all deep-sky objects, including galaxies. The **LUMICON UHC Filter**™ is for viewing only and yields the highest contrast for planetary and emission nebulae of any filter available today.

Filter Type	UHC	Deep-Sky
For 0.965" eyepieces	—	$49.95
For 1¼" eyepieces	$79.50	$59.50
48mm for 2" eyepieces	$129.50	$99.50
For 2" eyepieces & photography		$99.50
Set, 1¼" UHC & Deep-Sky Filters		$125.00
Selected premium filters		add $20

H-Beta Filter, 1¼" . . . **$79** 48mm . **$129**

H-ALPHA PASS FILTER

Yields spectacular contrast gains in B&W photography with telephoto lenses. Yields pinpoint star images. Superb with hypered 2415. For color, use the Minus Violet (MV) Filter.

Specify Lens Size	H-Alpha	(MV)
46, 48, 49mm	$29.95	$25.00
52, 55, 58, 62mm	$39.95	$29.95
67, 72, 77mm	$46.95	$39.95
82mm	$49.95	

Hypered 2415 film, 36 exp . . . **$9.95** . . . **3/$27**

TELE VUE™ EYEPIECES USE THE BEST!!

ALL IN STOCK

Plossl, Wide-Field, Nagler Eyepieces
7.4, 10.4, 13, 17, 21, 26mm Plossl(50°) . . . **$65**
2½ X Tele Vue Barlow Lens **$65**
32mm Plossl, widest true field in 1¼" . . **$80**
55mm 2" Plossl, widest possible field . **$160**
19mm Wide-Field, 1¼" eyepiece (65°) . **$110**
24mm Wide-Field, "superb" (65°) **$125**
32mm Wide-Field, 2" eyepiece (65°) . . . **$195**
40mm Wide-Field, "awesome" (65°) . . . **$250**
4.8mm Nagler, *82°* field **$125**
9mm Nagler, 82° field, "the best" **$195**
13mm Nagler, 82° field, 1¼" or 2" **$220**
(apparent field of view in parenthesis)

LUMICON®
2111 Research Drive #5A, Livermore, CA 94550
For phone orders please call (415) 447-9570
LUMICON Products catalogue $2.
Foreign orders add 6% ($20 for HYPER-KITS)
California Residents add 6% tax.
Prices subject to change w/o notice.

SUPER-FINDER™

The LUMICON SUPER-FINDER is both a compact Rich-Field Telescope and a magnificent "Super-Finder." It has a fully coated 80mm achromatic lens and 300mm focal length. The Deluxe SUPER-FINDER has a superb 500mm f/6 air-spaced lens.

12X80mm SUPER-FINDER **$169.50**
1¼" SUPER-FINDER w/o eyepiece **$149.50**
1¼" Right-angle SUPER-FINDER* **$149.50**
2" Right-angle SUPER-FINDER* . . **$179.50**
1¼" DELUXE SUPER-FINDER* . . . **$239.50**
2"/1¼" DELUXE SUPER-FINDER* . **$289.50**
**Requires a 1¼" or 2" star diagonal*
1¼" star diagonal, 30mm aperture . **$28.95**
1¼" enhanced silver mirror diagonal . **$79.50**
2" LUMICON enhanced silver mirror-type star diagonal takes 48mm filters **add $99.50**
Mounting rings, 3-5/8" I.D. **$16.95/pair**
Mounting adapter for C-8, Meade, etc. . **$35**

DEEP-SKY ASTROPHOTOGRAPHY

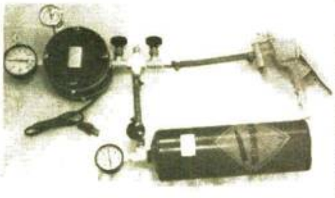
FILM HYPERSENSITIZATION KITS†

LUMICON HYPER-KITS™ yield 3-15X film speed gain in long exposures. They are safe & simple to use. Easy HYPER-KIT includes a chamber with all controls and fittings, thermometer, a refillable cylinder of non-flammable forming gas & hand-operated vacuum pump.

†Patent Pending

MODEL 100 HYPER-KIT for 35mm film, rolled-up. *Takes longer*, but it easy to use. Not recommended for 2415......... **$225.00**

MODEL 300 HYPER-KIT sensitizes any 35mm film in hours. Best for 2415. Achieves highest possible film speeds **$275.00**



MODEL 600 HYPER-KIT [See Photo] Like the Model 300, but also sensitizes 120/220 larger format film and small glass plates **$299.50**

MODEL 1200 HYPER-KIT is for 4X5" plates and film up to 5X7". Has 2 gas cylinders and includes temperature controller . . . **$525.00**

Temperature controller for any HYPER-KIT **$59.50**

Electric Vacuum Pump **$265.00**

GUIDE OFF-AXIS FOR LOVELY ASTROPHOTOS

All **LUMICON EASY-GUIDER**™ off-axis guiders† have both radial and 360° rotational adjustments for 5X eaiser guide-star selection, use 48mm filters, 360° camera rotation, large prisms fo bright guide-starts. *Specify Camera and Telescope type.*
U.S. Patent # 4,448,500

NEWTONIAN EASY-GUIDER™

Full aperature. Installs in secs. Specify 2" or 1¼".

NEWTONIAN EASY-GUIDER **$149.50**
3X Relay Diagonal [See Photo] **$69.50**
Illuminated reticle eyepiece system . **$59.50**

CASSEGRAIN EASY-GUIDER™

For C-8, Meade 2080, Dynamax-8. Includes 50mm achromatic lens for f/5.8 operation-3X shorter exposures! **Superb rich field viewing, too!**

CASSEGRAIN EASY-GUIDER **$199.50**

GIANT EASY-GUIDER™

For Celestron-11, C-14, and the 10" Meade 2120. Includes 80mm clear aperture achromatic lens for edge-to-edge illumination & pin-point star images. F-ratio adjustable f/4-f/11. **Also yields unmatched Rich-Field viewing.**

GIANT EASY-GUIDER **$359.50**
48mm DEEP-SKY Filter ordered with any EASY-GUIDER [SAVE $20] ...... **add $79.95**

WHAT DO YOU NEED?

1. **Illuminated reticle eyepiece** **$59.50**
Lumicon 12mm eyepiece system has adjustible L.E.D. illumiation, dual crosslines, battery pack.
2. Cable release for long exposures . **$9.95**

3. **Lumicon Quartz Drive Corrector** . . . **$198**
Dual-axis drive corrector is essential for astrophotography and/or field use of your telescope. 40Hz/80Hz variable output controls telescope drive. 60Hz Quartz reference, ± 12V.D.C. Declination control output. Both 110VAC and 12VDC input for home or field use. Declination reverse switch for Newtonians.
Declination moter (specify telescope) . **$60**

Kodak
TP 135-36
400
Kodacolor VR
1000
12

HYPERSENSITIZED FILM

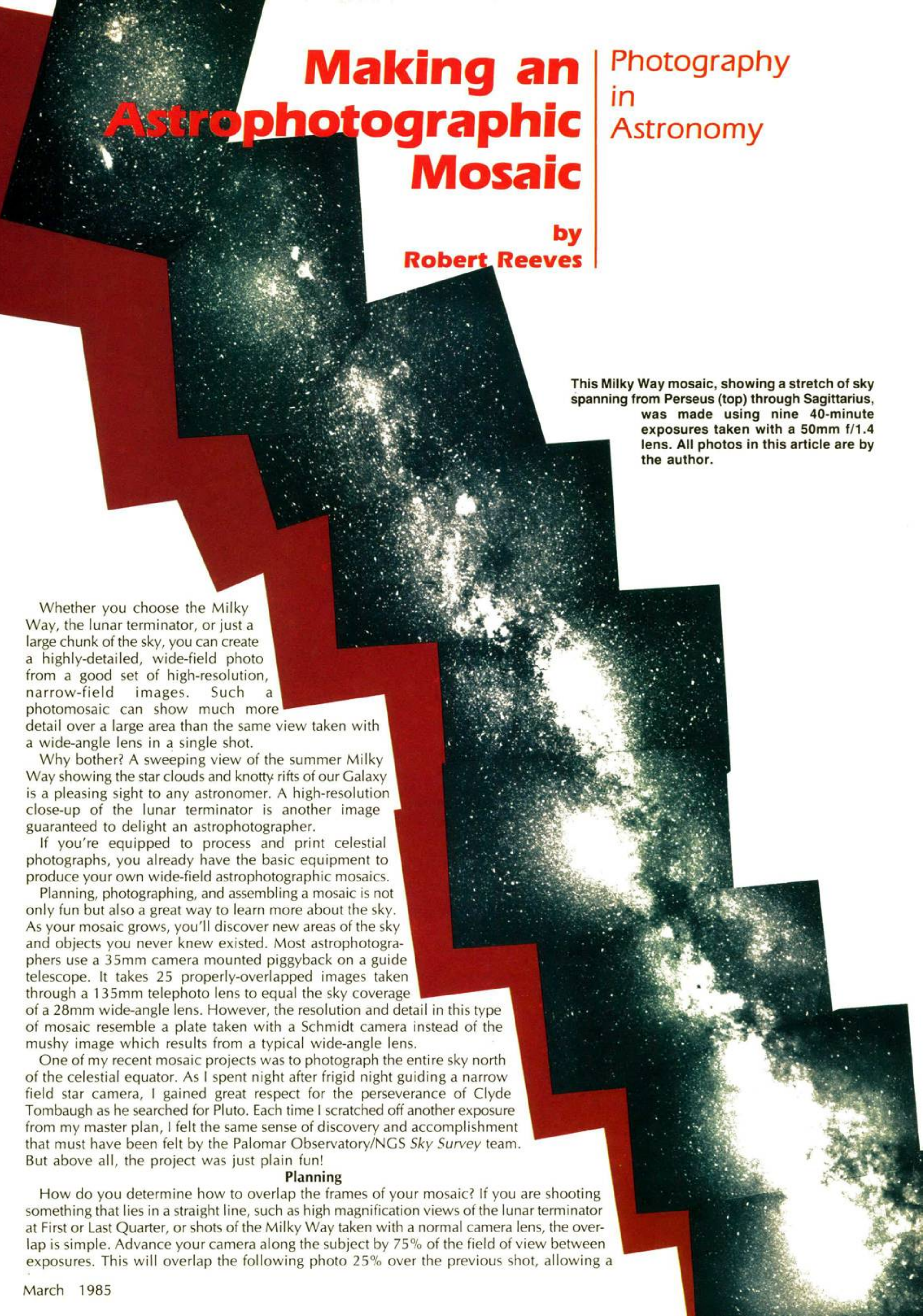
LUMICON Hypersensitized film is essential for good deep-sky astrophotography.

Film Type (35mm unless marked)	Exposures	Price
2415, Ultra-fine B&W, red sens	36	$9.95
VR200 fine grain color negs	12	$9.95
Fujichrome 400, "Excellent"	20	$12.95
VR1000, fastest of all, color negs	12	$12.95
5072, color slides from negs	36	$6.95
D-19 B&W Developer, 1 gal.		$5.95

Photography in Astronomy

Making an Astrophotographic Mosaic

by
Robert Reeves



This Milky Way mosaic, showing a stretch of sky spanning from Perseus (top) through Sagittarius, was made using nine 40-minute exposures taken with a 50mm f/1.4 lens. All photos in this article are by the author.

Whether you choose the Milky Way, the lunar terminator, or just a large chunk of the sky, you can create a highly-detailed, wide-field photo from a good set of high-resolution, narrow-field images. Such a photomosaic can show much more detail over a large area than the same view taken with a wide-angle lens in a single shot.

Why bother? A sweeping view of the summer Milky Way showing the star clouds and knotty rifts of our Galaxy is a pleasing sight to any astronomer. A high-resolution close-up of the lunar terminator is another image guaranteed to delight an astrophotographer.

If you're equipped to process and print celestial photographs, you already have the basic equipment to produce your own wide-field astrophotographic mosaics.

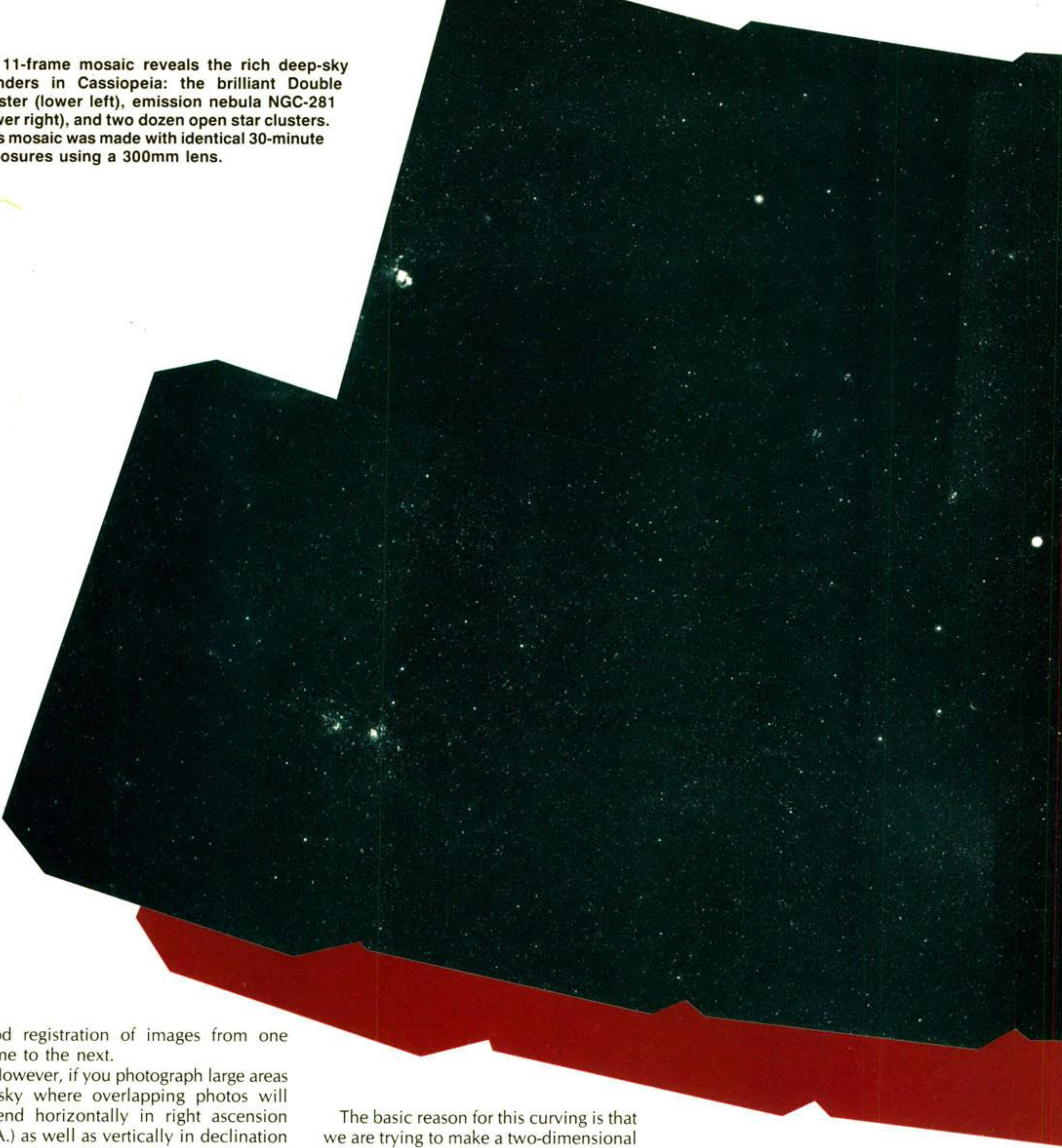
Planning, photographing, and assembling a mosaic is not only fun but also a great way to learn more about the sky. As your mosaic grows, you'll discover new areas of the sky and objects you never knew existed. Most astrophotographers use a 35mm camera mounted piggyback on a guide telescope. It takes 25 properly-overlapped images taken through a 135mm telephoto lens to equal the sky coverage of a 28mm wide-angle lens. However, the resolution and detail in this type of mosaic resemble a plate taken with a Schmidt camera instead of the mushy image which results from a typical wide-angle lens.

One of my recent mosaic projects was to photograph the entire sky north of the celestial equator. As I spent night after frigid night guiding a narrow field star camera, I gained great respect for the perseverance of Clyde Tombaugh as he searched for Pluto. Each time I scratched off another exposure from my master plan, I felt the same sense of discovery and accomplishment that must have been felt by the Palomar Observatory/NGS *Sky Survey* team. But above all, the project was just plain fun!

Planning

How do you determine how to overlap the frames of your mosaic? If you are shooting something that lies in a straight line, such as high magnification views of the lunar terminator at First or Last Quarter, or shots of the Milky Way taken with a normal camera lens, the overlap is simple. Advance your camera along the subject by 75% of the field of view between exposures. This will overlap the following photo 25% over the previous shot, allowing a

An 11-frame mosaic reveals the rich deep-sky wonders in Cassiopeia: the brilliant Double Cluster (lower left), emission nebula NGC-281 (lower right), and two dozen open star clusters. This mosaic was made with identical 30-minute exposures using a 300mm lens.



good registration of images from one frame to the next.

However, if you photograph large areas of sky where overlapping photos will extend horizontally in right ascension (R.A.) as well as vertically in declination (Dec.), then advance planning with a star chart is required. Using the star chart and details we'll discuss later, you will need to set up a coordinate grid to plan your mosaic.

Before doing that, let's examine the geometry behind celestial mosaics. Weird things happen to mosaics that cover more than one straight line of photos. Without good planning, rows of photos spaced to give 25% overlap at the equator will overlap by up to 90% near the pole.

Near the poles, adjacent photos aligned for east-west converge, appear to curve. This results from the same effect that causes the northern declinations to be shown as curves and circles on star charts, like *Sky Atlas 2000.0*, while the equatorial regions show as straight lines.

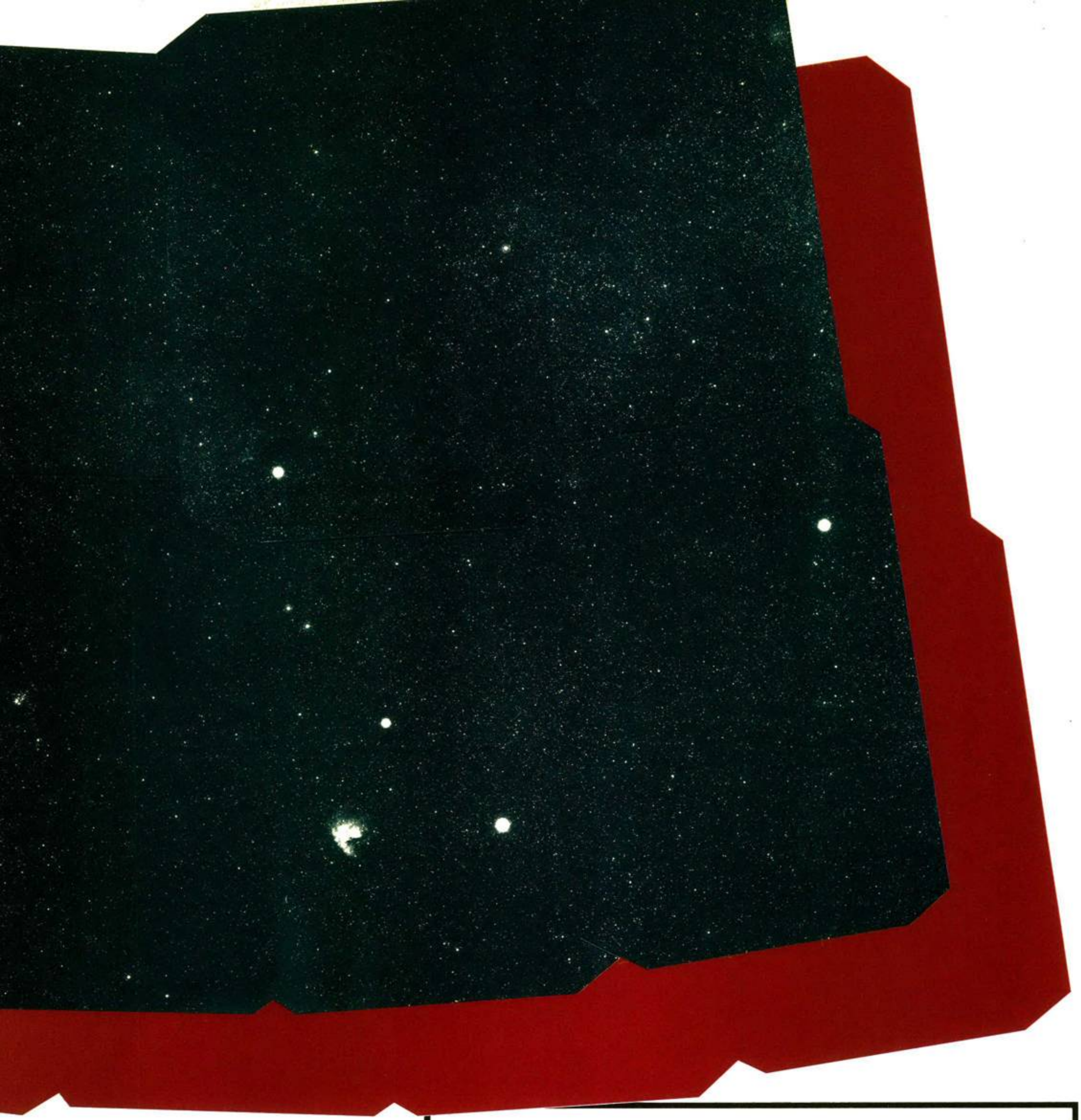
The basic reason for this curving is that we are trying to make a two-dimensional representation of a three-dimensional object. We perceive the sky as the inside of a sphere. As we photograph small areas of the sky and assemble them into a mosaic, we are trying to represent this curved, three-dimensional object using a flat, two-dimensional photograph.

Laying Out the Grid

Because of this curving, there is a practical limit to how much sky we can assemble into a flat mosaic. In reality, areas covering several large constellations can be assembled without difficulty. Larger areas don't fit at the edges. To solve this problem, you must assemble the mosaic photos on a spherical surface whose diameter, based on the size of the photos equals that of the celestial sphere.

However, the intent of our astro-mosaic efforts is not to make a celestial globe, but to photograph large areas of the sky to achieve fine detail not possible with a wide-angle lens. How do we plan the coordinate grid for our celestial mosaic? The overlap in declination is easy to calculate. Simply raise or lower the camera's field of view by 75% of the north-south viewing angle of the lens. As seen in the table at right, the vertical field of view for a 135mm lens is 12°, so succeeding shots in declination would be moved up or down 75% of this angle, or 9°, between overlapping frames.

To determine the overlap required in R.A., refer again to the table. We see the horizontal field of view for a 135mm lens is 18°. We also see this 18° field of view



covers one hour and twelve minutes of R.A. at the celestial equator. To find the approximate width of the field of view (in units of R.A.) at higher declinations, divide the field width at the equator by the cosine of the declination. Although this approximation breaks down at high declinations where the curvature of the lines of constant declination becomes extreme, it works fine for our purposes.

Using this method, we find the field of view in R.A. for a 135mm lens slowly expands from one hour and twelve minutes at the celestial equator to about one hour and thirty-four minutes at 40° declination. However, its field balloons to six hours and fifty-four minutes at 80° declination.

Field of View in R.A. at Increasing Declinations

Dec	**0°**	**30°**	**50°**	**60°**	**70°**	**80°**
Cosine	**1.00**	**.866**	**.643**	**.500**	**.342**	**.174**
50 mm	3h 04m	3h 32m	4h 46m	6h 08m	8h 58m	17h 36m
85 mm	1h 54m	2h 11m	2h 57m	3h 48m	5h 33m	10h 55m
135 mm	1h 12m	1h 23m	1h 52m	2h 24m	3h 30m	6h 54m
200 mm	50m	57m	1h 17m	1h 40m	2h 26m	4h 47m
300 mm	32m	37m	50m	1h 04m	1h 33m	3h 04m

The table below shows the approximate field widths in R.A. for various lenses. Using this and the 25% overlap rule for declination, as well as R.A., we can now set up the required grid for a wide-field mosaic using a narrow-field lens.

Shooting the Exposures

Once you decide what area of the sky your astro-mosaic will cover, observe one basic rule when shooting: Stop down your camera lens two f/stops from wide open to increase the sharpness of star images. This will also reduce the "hotspot" that appears in the center of celestial photos due to light fall-off near the edge of the lens' field of view. If you don't stop down, your assembled mosaic will look like a collection of cotton balls. Even with the use of filters that increase the sharpness of stellar images, such as a minus-violet or an Hα filter, stopping down the lens is still a must to reduce the vignetting in individual exposures.

Printing: Consistency Is the Key

After the planning and photography is completed, the next step is printing your mosaic. To give the finished mosaic a snappy appearance, print the exposures on the highest contrast printing paper available, and of course, at the same scale. The key to processing the mosaic segments is consistency. Print the mosaic pieces in the order they will appear on the finished product. This allows you to match the density of succeeding prints so none will stand out as too light or dark compared to the others. To help maintain consistency, make sure you develop each print fully — let it stay in the developer for 60 to 90 seconds. Any less means you have overexposed your print. When the prints are dry, trim off the borders with a sharp paper cutter, good pair of scissors, or an X-acto or matt knife and a straightedge.

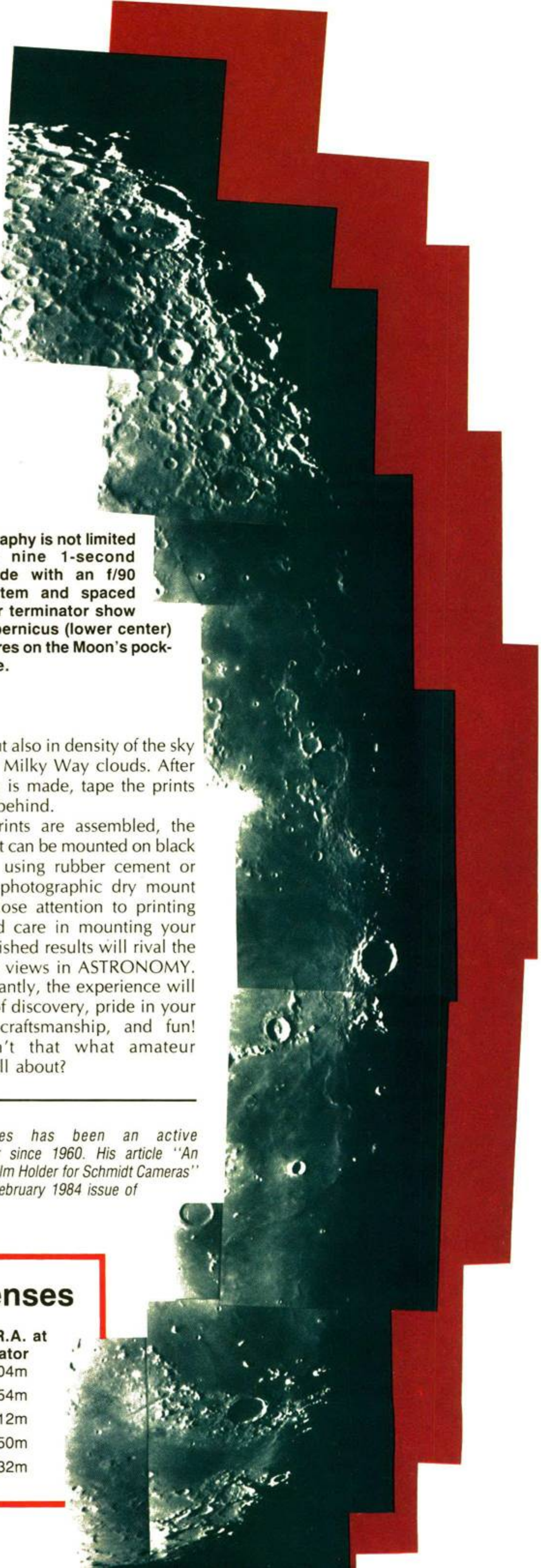
Assembling the Mosaic

After trimming the mosaic photos, use a black felt-tipped marker to darken the freshly-cut edge of the prints. This is done so the print backing will not show as white lines across the finished mosaic. The initial assembly to secure the overlapping images on each other can be done with cellophane tape. Overlap the adjoining prints alternately, left print over right, then right print over left, until you find the combination that matches best. Succeeding prints should match not only in alignment but also in density of the sky background or Milky Way clouds. After the best match is made, tape the prints together from behind.

Once the prints are assembled, the finished product can be mounted on black matting board using rubber cement or (much better) photographic dry mount tissue. With close attention to printing techniques and care in mounting your mosaic, the finished results will rival the best wide-field views in ASTRONOMY.

More importantly, the experience will bring a sense of discovery, pride in your photographic craftsmanship, and fun! After all, isn't that what amateur astronomy is all about?

Robert Reeves has been an active astrophotographer since 1960. His article "An Inexpensive Roll Film Holder for Schmidt Cameras" appeared in the February 1984 issue of ASTRONOMY.



Mosaic photography is not limited to starfields: nine 1-second exposures made with an f/90 projection system and spaced along the lunar terminator show sunrise on Copernicus (lower center) and other features on the Moon's pockmarked surface.

Field of View for Popular Lenses

Focal Length	Field Width	Field Height	Field R.A. at Equator
50 mm	46°	30.5°	3h 04m
85 mm	28.5°	19°	1h 54m
135 mm	18°	12°	1h 12m
200 mm	12.5°	8.5°	50m
300 mm	8°	5.5°	32m

Bring the Entire Night Sky into Your Home

Nearly 6,000 stars — every star visible to the naked eye — are plotted on **The Star Map**'s 30 x 60 inch black diazo surface. Each star is scaled in size to indicate its apparent brightness — so they appear just as they do in the night sky. And all major stars and constellations are labeled for easy reference.

The Star Map — A functional and attractive tool for the beginning or the veteran stargazer.

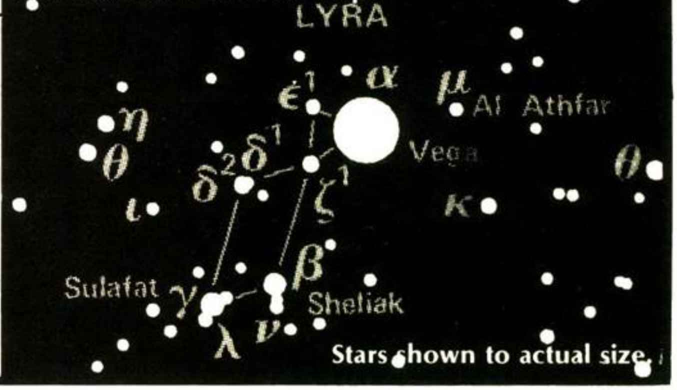
$12.95

Shipped in a sturdy tube

To order, use the AstroMedia order form bound into this issue or send to AstroMedia Corp., Order Dept., P.O. 92788, Milwaukee, WI 53202.

Star Map copyright © David W. Teske, 1979. All rights reserved.

Lyra section of The Star Map.



Stars shown to actual size.

EASY TO ORDER . . . Phone or mail your order in today. Visa/Mastercards accepted. All telescopes and mounts are shipped shipping charges collect. All mirrors, except the 29", are shipped prepaid in the contínguous U.S.A. No sales tax on out-of-state orders. FREE LIST.

Showroom address: 54140 Pinecrest Road, Idyllwild
Mon.-Fri. 8 am-4:30 pm. Sat. 12-4 pm.

ODYSSEY

Visual High Fidelity Telescopes

- **30 days returnable**
- **30 days exchangable**
- **2 years materials and workmanship**

"NEVER TOO SMALL"

NEW! ODYSSEY 8 INCH

$239.50

"THE WORLD'S GREATEST TELESCOPE VALUE!"*

SPECIFICATIONS

- 8" f/4.5 paraboloidal mirror with matching diagonal flat, both 1/8 wave, aluminized and overcoated.
- Super smooth and stable Dobsonian alt-azimuth mount with linear U.H.M.W. bearings. No play or backlash.
- Adaptable to astrophotography with accessories.
- Coated high performance 27mm Kellner eyepiece with chromed brass and cast aluminum 1¼" rack-and-pinion focuser.
- Durable solid white seamless plastic vinyl tube.
- Adjustable ventilated push-pull shock resistant mirror cell.
- Beautiful black, white and metallic finish.

*Aperture is the key to performance. More aperture means more light and more resolution. In comparing all the small and medium size telescopes advertised in both Astronomy and Sky and Telescope magazines, we discovered that the Odyssey 8 has the lowest cost per sq. inch of aperture. The results were dramatic! One popular 4⅛" telescope costs $14.92 per sq. inch—3 times the cost of the Odyssey 8's $4.76 per sq. inch!

LARGE APERTURE

LARGE APERTURE is the key to the success of these fine telescopes. In their sizes, they are the largest-selling low-priced telescopes in the world today.

- 1/8 wave mirror optics
- Super smooth and stable Dobsonian mounts
- Adaptable to astrophotography with accessories
- High performance coated 27mm Kellner eyepiece with precision 1¼" focuser
- Beautiful Zolatone blue finish accented with black and metallic surfaces

10.1" ODYSSEY COMPACT

This scaled-down version of the Odyssey I performs very close to its larger brother. Because of its size, it is one of a few telescopes that can be used comfortably by an observer seated in a chair. Where space, size, weight and cost are considerations, this telescope will easily put you in the large aperture class. Fantastic views of galaxies, nebulae and star clusters are the menu of the telescope.

$299.50

13.1" ODYSSEY I

This is the telescope that started it all in the spring of 1980. Experienced deep-sky observers will tell you that you'll be amazed at what you can see under a good night sky. The challenge is not to see the lime-greens in M-42, but to detect the purple-pinks, the yellow-greens, and the subtle blues. In this size telescope there is not another available that gives you so much performance at such a low, low price.

$499.50

17.5" ODYSSEY II

Here is an unusual telescope at a low, low price. The core of this telescope is the world's most popular large aperture mirror set—the famous 17.5" f/4.5. Until recently this telescope sold for $1,195.00. We reduced the price $200.00. At $995.00 it is only $335.00 more than the mirror set! Shows colors in the Ring Nebula, two or three dust lanes in M-31, and globular clusters as they should be seen.

$995.00

29" ODYSSEY 29

The world's largest production telescope. It was with this telescope that we first saw color in the Veil Nebula. This telescope gives the observer an illusion of being in space more powerful than any other telescope we've observed with. Literally outperforms any other production telescope available in the world today.

$3495.00

Coulter Optical Co.

Dept. A, P.O. Box K
Idyllwild, CA 92349
714/659-4621

"OPTIMUM OPTICS AT MINIMUM COST SINCE 1967"

ASTRONOMICAL OPTICS

Lightweight Mirror Optics at Low, Low Prices: Pyrex, ⅛ wave, aluminized & overcoated

13.1 inch f/4.5 mirror	$254.50
12.5 inch f/6 mirror	$249.50
10.1 inch f/4.5 mirror	$134.50
10 inch f/5.6 mirror	$129.50
29 inch f/4.5 mirror	$2490.00
with diagonal	16-1 Ratio
17.5 inch f/4.5 mirror	$659.50
with diagonal	13-1 Ratio

Elliptical Diagonals

1.83"	$15.50	3.10"	$34.50
2.14"	$18.95	4.25"	$69.50
2.60"	$22.50	6.25"	$150.00

NEW! EQUATORIAL MOUNTS

- All metal
- 2" dia. shafts
- Hollow polar shaft
- Adjustable latitude
- Super sturdy, yet lightweight
- Single arm 10.1" mount
- Double arm 13.1" mount

Compact—$249.50

Odyssey I—$379.50

ASTRONOMY
Products for Observers

NEW

The Rand McNally *Starfinder* Celestial Globe

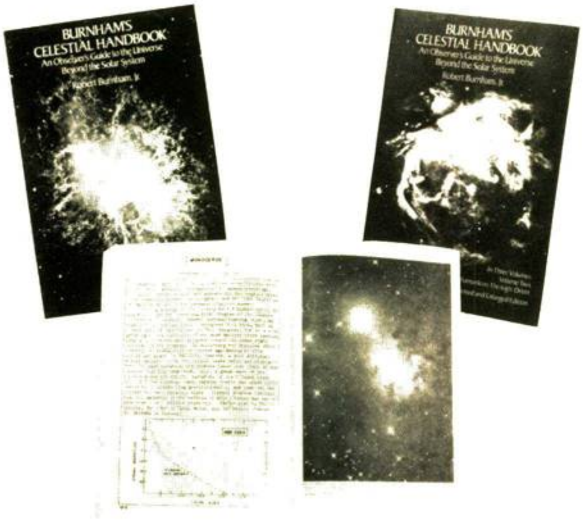
This deluxe 12-inch diameter celestial globe combines an accurate map of the starry heavens with the ancient figures from mythology. Printed with yellow stars, a deep-blue sky, and light-blue mythological figures, you'll treasure this beautiful and practical accessory for a lifetime.

Informative and easy to use, the STARFINDER celestial globe proclaims your involvement in astronomy!

- Track the everchanging parade of constellations
- Follow the yearly path of the Sun through the zodiac
- Plot the movements of the Moon and planets
- Tilt the mounting to display the sky visible from anywhere on Earth

The Rand McNally STARFINDER celestial globe always looks splendid — on your desk, in your living room, in the den. Order yours today! Includes instruction manual.

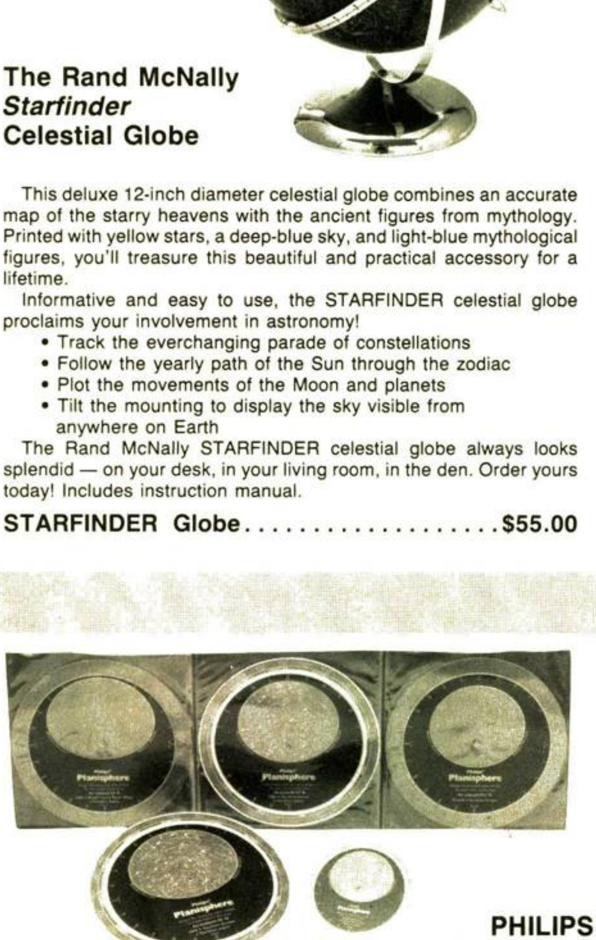
STARFINDER Globe.................. $55.00


BURNHAM'S CELESTIAL HANDBOOK
An Observer's Guide to the Universe Beyond the Solar System
Robert Burnham, Jr.
BURNHAM'S CELESTIAL HANDBOOK
An Observer's Guide to the Universe Beyond the Solar System
Robert Burnham, Jr.

BURNHAM'S CELESTIAL HANDBOOK: Burnham. The great modern classic about deep-sky objects; each constellation has an introductory section with descriptions of double and multiple stars, variable stars, star clusters, nebulae and galaxies. Includes photographs, tables, graphs and finder charts — a must for your library. 3 volumes, 2138 pages in all, paperback.

Vol. 1 — Andromeda through Cetus
Vol. 2 — Chamaeleon through Orion
Vol. 3 — Pavo through Vulpecula

Vol. 1, $10.50; Vol. 2, $11.50; Vol. 3, $12.50


Planisphere
Planisphere
Planisphere
Planisphere

PHILIPS' PLANISPHERES

A **Philips' Planisphere** shows you the principal stars and constellations visible for every hour in the year. Just rotate the 2 plastic discs until the hour and date coincide. You can see what time Leo rises in mid-January, when the Pleiades set in May — "what's up" at any time, on any date.

Lightweight and made of waterproof plastic, a planisphere is portable and durable enough to be taken anywhere — backpacking, sailing or your own backyard.

The 10" diameter size is available in 3 latitudes: 52°, 42° and 32°. The 5" pocket-size model is available in 42° and 32° ranges only. PLEASE SPECIFY LATITUDE.

10" PHILIPS' PLANISPHERE 52°, 42° or 32° $8.95
5" PHILIPS' PLANISPHERE 42° or 32° ... $5.95

NEW! PHILIPS' DELUXE PLANISPHERE. For the travelling observer — 3 planispheres in one! Has the same high-quality features found in the standard models, PLUS interchangeable overlay discs for accuracy almost anywhere in the Northern Hemisphere. Includes snap-on overlays for 32°, 42° and 52° and comes in an album-style pouch. **$14.95**

THE STAR BOOK
by Robert Burnham
Algol
AstroMedia | Cambridge University Press

THE STAR BOOK

Learn the constellations with **THE STAR BOOK**, from AstroMedia. 8 charts cover all seasons, providing enough overlap for easy identification of prominent star patterns. Each map is accompanied by a description of the stars, the constellations and their lore and legends written by ASTRONOMY's Robert Burnham.

- **all northern constellations shown**
- **easy to use at night**
- **10" x 11¼"**
- **folds back for your convenience**
- **printed in two colors on thick cardstock**
- **coated with a durable water-resistant varnish**
- **heavy-duty wire binding**
- **will give years and years of service**

THE STAR BOOK..................... $6.95

Foreign orders add $1.50

A Starhopper's Guide To MESSIER OBJECTS
By Lenore

A STARHOPPER'S GUIDE TO MESSIER OBJECTS: Freeman. Shows you how to locate each of the 110 Messier objects by "hopping" to them from easy-to-find bright stars. Uses only the naked-eye stars of each constellation. 23 pages, paperback. **$7.50**

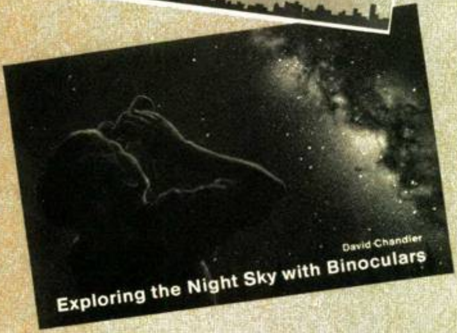
Observing EARTH SATELLITES
CELESTIAL OBJECTS FOR COMMON TELESCOPES
BY THE REV. T. W. WEBB
IN TWO VOLUMES
VOLUME ONE: THE SOLAR SYSTEM
CELESTIAL OBJECTS FOR COMMON TELESCOPES
BY THE REV. T. W. WEBB
EDITED AND REVISED BY MARGARET W. MAYALL
IN TWO VOLUMES
VOLUME TWO: THE ST

OBSERVING EARTH SATELLITES: King-Hele. From the first Sputnik launch in 1957 to the Shuttle and Salyut space stations, the number of satellites orbiting the Earth has grown to over 5,000. Many are visible from the ground, and this is a practical guide for anyone who wants to follow them — using naked eyesight or binoculars. 184 pages, hardcover. **$16.95**

SEASONAL STAR CHARTS
A COMPLETE GUIDE TO THE STARS

SEASONAL STAR CHARTS. Guide to the heavens with 8 star maps and accompanying lists of objects in each constellation; has Star Finder planisphere on cover. 23 pages, plasticized paper, ring-bound to lie flat. **$8.50**

CELESTIAL OBJECTS FOR COMMON TELESCOPES: Webb. This classic covers the solar system (the Sun, Moon, planets, comets and meteors) as well as observing with a telescope in Volume 1, and deep-sky objects (grouped by constellation) in Volume 2. Valued as much for style as for content, *Webb's* is a book for every telescope owner. 606 pages in all, paperback. **$11.00 (set)**


David Chandler
Exploring the Night Sky with Binoculars

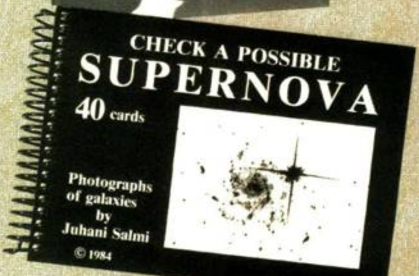
EXPLORING THE NIGHT SKY WITH BINOCULARS: Chandler. Introduces the beginning stargazer to observational astronomy with a clearly-written text illustrated with handsome diagrams. Includes a good resource guide for further reading. 47 pages, paperback. **$4.95**

OBSERVING VISUAL DOUBLE STARS
Paul Couteau

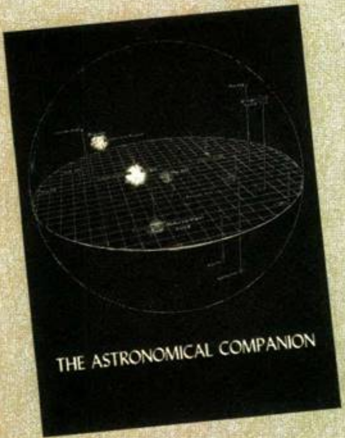
OBSERVING VISUAL DOUBLE STARS: Couteau. Written by an astronomer who has discovered almost 2,000 double stars, this book opens the way for any backyard observer who wants to share in the fascination of these beautiful stellar objects — and make a contribution to science. Full of practical advice and useful tables, this is a handbook no double-star observer should be without. 257 pages, paperback. **$9.95**

The nature of
LIGHT & COLOR
in the open air
M. Minnaert
mirages, haloes, shadows, double rainbows... hundreds of other phenomena visible with the naked eye ...explained by a famous physicist

THE NATURE OF LIGHT AND COLOR IN THE OPEN AIR: Minnaert. A sky-watcher's classic for over 30 years! Tells all about "atmospheric optics" — rainbows, sundogs, mirages, multiple Moons, colored shadows, irridescent clouds, the green flash, and lots, lots more. Dozens of atmospheric phenomena — including some which are quite rare — are clearly and simply explained. 362 pages, paperback. **$6.50**


CHECK A POSSIBLE SUPERNOVA
40 cards
Photographs of galaxies by Juhani Salmi
© 1984

CHECK A POSSIBLE SUPERNOVA: Salmi. Searching for supernovae has become one of the hottest fields of activity for amateur astronomers. All it takes is a 6-inch or larger telescope, patience, and a guidebook that shows what galaxies look like. This "album" of 40 galaxies is an ideal place to start. 40 b&w photos printed on cardstock, wire-bound. **$6.95**


THE ASTRONOMICAL COMPANION

THE ASTRONOMICAL COMPANION: Ottewell. Large-format book that shows how the Earth relates to other planets, comets, nearby stars and neighboring galaxies. Provides superb visual perspectives with 30 large drawings and numerous smaller ones. 73 pages, paperback. **$12.50**

The Best Deep-Sky Objects

THE BEST DEEP-SKY OBJECTS: This handy card, printed on heavy stock and varnished for durability, shows where all the Messier objects are in the sky — plus the 51 best objects in the *New General Catalogue*. The front side displays them on an all-sky map (with an inset for the Coma-Virgo cluster of galaxies); the reverse tabulates each object and gives epoch 2000.0 positions, magnitudes, sizes, observing difficulty, type of object, constellations, and nickname.
$1.50 each or 50¢ each for 5 or more

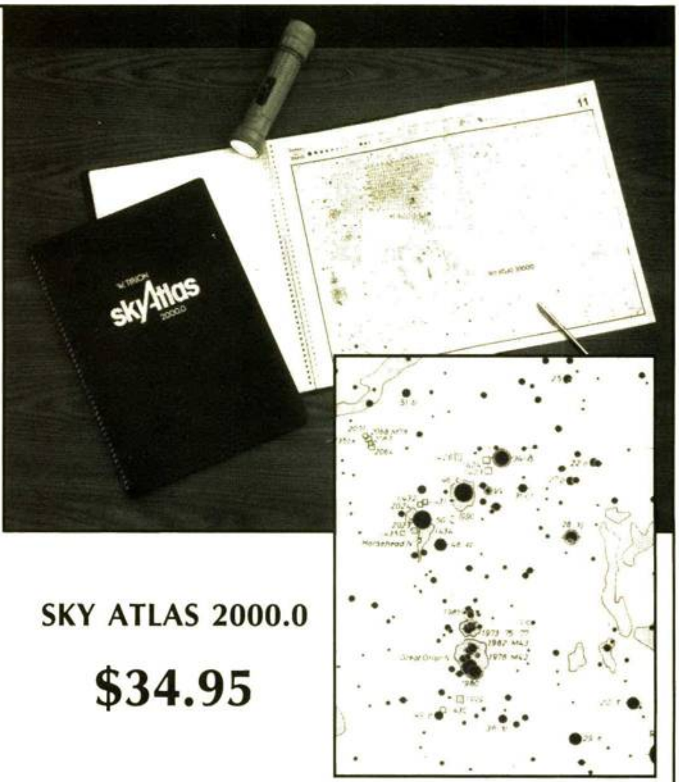
To order any item on these 2 pages, use the AstroMedia order form bound into this magazine, or send to AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

Sky Atlas 2000.0

Join the ranks of knowledgeable amateur astronomers with the **Sky Atlas 2000.0**. Find your way to galaxies, star clusters, and nebulae with ease. These giant star maps are crisp and distinct — and they're beautifully illustrated in color. Even the armchair astronomer will enjoy tracking down favorite nebulae and galaxies and other celestial objects seen in ASTRONOMY.

- 26 charts encompassing both hemispheres
- Each jumbo chart 12½" x 17½"
- 43,000 stars — to the 8th magnitude
- 2,500 color-coded deep-sky objects
- Clearly-defined constellation boundaries
- All Messier objects and thousands of NGC objects
- Celestial coordinates for the year 2000
- Handy reference key on each chart

Also available: **Sky Catalogue 2000.0**. 632 pages of information on over 45,000 stars — including positions, spectral type, and distance. Paperback, **$29.95.**



SKY ATLAS 2000.0

$34.95

U.S. Postage included — Foreign add $2.00

To order, use the AstroMedia order form bound into this magazine, or send to: AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

Tele Vue™ ***. . . Even better than you imagined!***

VUE 24MM WIDE FIELD

TELE VUE 65° WIDE FIELD EYEPIECES

19mm 24mm
32mm (2") 40mm (2")

"FIRST WIDE ANGLE EYEPIECE WITH SNAP IMAGING"

—John Vogt, NY

VUE 32MM PLÖSSL

TELE VUE 50° PLÖSSL EYEPIECES

7.4mm 10.4mm 13mm 17mm 21mm 26mm 32mm 40mm
55mm (2" BARREL) and 2.5x BARLOW

"SHARPEST I'VE EVER USED"

—From Review in Aug. 81 "ASTRONOMY"

TELE VUE NAGLER

TELE VUE 82° NAGLER EYEPIECES

4.8mm 9mm 13mm

"THE NAGLER 13 — — A REMARKABLE TELESCOPE EYEPIECE"

Title of 8 Page Article in "TELESCOPE MAKING" Magazine, Issue #20, Fall '83

Ask any owner or Tele Vue Dealer why Tele Vue eyepieces provide the most exciting views you've ever seen, regardless of size or type of telescope. Guaranteed superior!

Send now for our free color literature that shows you how to choose the best eyepieces for your telescope. We also make 2" diagonals with adapters for Meade and Celestron scopes and focussing Questar adapters.

Tele Vue 20-A DEXTER PLAZA, PEARL RIVER, NY 10965

PH. 914-735-4044

CELESTRON: THE BEST IS NOW THE MOST BEAUTIFUL

When they were introduced, Celestron's line of catadioptric telescopes captured the minds and hearts of amateur astronomers everywhere. They provided excellent images. With crisp resolution. Color-perfect optics. And best of all, they were extremely compact, portable and reasonably priced.

Celestron's C90, C5, C8, C11 and C14 quickly became the standard by which all others were judged. While imitators have appeared, Celestron has quietly—and superbly—refined the line. Computer-designed optics and laser-testing were enhanced. Special star-bright coatings were added. New finder-scopes and mounts became available. Even an ultra-precise Byers worm gear drive base was specially developed. The instruments became so astronomically refined, Celestron offered a limited lifetime warranty.

Then—and only then—have we turned our attention to making the best also the most beautiful. See for yourself—instruments that now capture the minds, hearts and eyes of amateur astronomers everywhere.

For Dealer Locations, Catalogs, Information,
Technical Data Sheets

CALL FREE 1-800-421-1526
(Mon-Fri; 8-4:00 Pacific Time; Continental USA only)

CELESTRON INTERNATIONAL
P.O. Box 3578B3B
2835 Columbia St.
Torrance, CA 90503
(213) 328-9560

CELESTRON®
PRECISION OPTICS

ASTRONEWS

Brown Dwarf "Star" Found

Astronomers have recently found evidence of a "brown dwarf" — an object that straddles the borderline between planet and star — in orbit around another star (see "Stars Too Small to Burn," ASTRONOMY, April 1984). This object may hold the key to two fundamental problems in astronomy today: the existence of other planetary systems like our own, and the nature of the "missing mass" in the universe.

Donald McCarthy Jr. and Frank J. Low of Steward Observatory and Ronald G. Probst of the National Optical Astronomy Observatories detected the object near the faint star van Biesbroeck 8. This star, called VB 8 for short, is named after astronomer George van Biesbroeck who discovered it in 1961. VB 8 lies 21 light-years from Earth in the constellation of Ophiuchus.

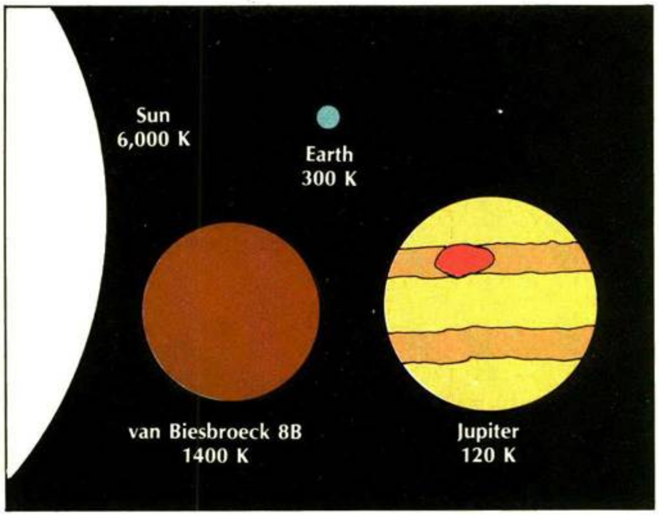
McCarthy, Low, and Probst used speckle interferometry to observe the brown dwarf at infrared wavelengths. The computer-assisted technique overcomes blurring caused by turbulence in the Earth's atmosphere. Such blurring would ordinarily hide a dim object in the scattered glare from a brighter close companion object.

The astronomers believe the object, dubbed VB 8B, is a gaseous body resembling Jupiter in appearance and substance. Although only about 90 percent the size of Jupiter, VB 8B is calculated to be 30 to 80 times more massive, and has a temperature of about 1400 Kelvin. In comparison, the Sun's surface temperature is about 6000 Kelvin.

In visible light, VB 8B is about 100,000 times fainter than its primary star, which in turn is roughly 10,000 times fainter than the faintest stars visible with the naked eye. But in the infrared, VB 8B is only 40 times fainter than its stellar companion. The two objects are separated by 600 million miles.

VB 8B is too dim and cool to be an ordinary star, says McCarthy. Its temperature, radius, and energy output more aptly place VB 8B in the extra-large planet category. Finding an intrinsically faint object such as VB 8B demonstrates that astronomers now have the instrumentation and techniques "to find lots of these things," notes McCarthy.

"Just finding one planet around one low-luminosity star that is completely unlike our Sun is a step in the right direction, but what astronomers ultimately want is to find many more substellar-mass brown dwarfs to help solve a number of intriguing astrophysical mysteries," he says.

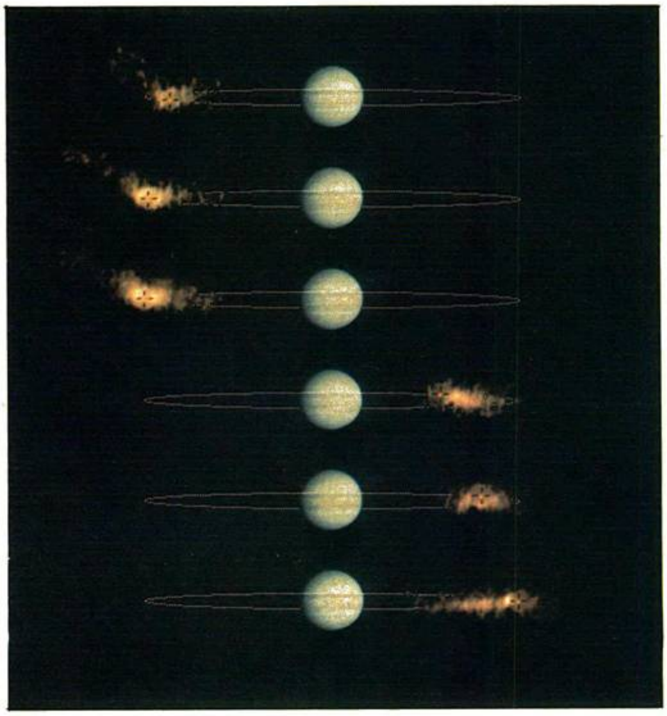


Among these questions are: How did our solar system come into being? Are there many planetary systems such as ours? (Last October, astronomers Bradford Smith and Richard Terrile announced photographic evidence of a possible planetary system around Beta Pictoris, a star 50 light-years from Earth. Although no planets were visible, the astronomers believe they may have formed and that this system is much younger than our own [see AstroNews, ASTRONOMY, January 1985]).

A second question is: Where — and what — is the so-called missing mass? Many theorists believe brown dwarf objects such as VB 8B may be part of the missing mass in the universe. They suspect the presence of invisible matter because many individual galaxies, and clusters of galaxies, have motions that hint they contain far more mass than can be seen. This unseen material has been termed the missing mass.

Related to the missing mass is a fundamental question in cosmology. If enough matter exists in the universe, its gravity will eventually halt the expansion created by the Big Bang. The universe could then collapse again into the ultra-dense state that initiated the Big Bang — and perhaps rebound once more.

The team hopes to find more objects like VB 8B. "If astronomers today think they understand how the universe formed — yet can't explain why most of the mass in the universe is invisible — they really aren't studying the right stuff," says McCarthy.



This shows the neutral sodium cloud that accompanies the jovian satellite Io, to scale with the planet. The dot in the crossbar reveals the location and size of Io; the dashed ellipse shows the satellite's orbit. Changes in the cloud's apparent size and shape are largely the result of perspective, but its structure also varies in response to changes in Io's environment. These pictures are from a movie currently being produced for the National Air and Space Museum in Washington, DC, to be shown this fall in the "Exploring the Planets" gallery. Bruce Goldberg acquired the data from observations made at JPL's Table Mountain Observatory, and Glenn Garneau and Susan LaVoie of JPL's Image Processing Laboratory generated the film.

Miracle at Halley?

International cooperation is a difficult and complex proposition in the best of times. And cooperation in space activities, because of the high level of national prestige and militarily useful technology involved, multiplies the usual problems even more. Launch windows do not wait and decisions seem to take forever, as each party maneuvers to gain the best possible advantage. But now and then, the advantages of cooperation so clearly outweigh the disadvantages that agreement seems almost preordained.

One project that seems to be gaining this cooperation is the spacecraft reconnaissance of Comet Halley. The European Space Agency's *Bulletin* recently published three papers on the navigation of Europe's comet probe Giotto — and all emphasize the role of international cooperation.

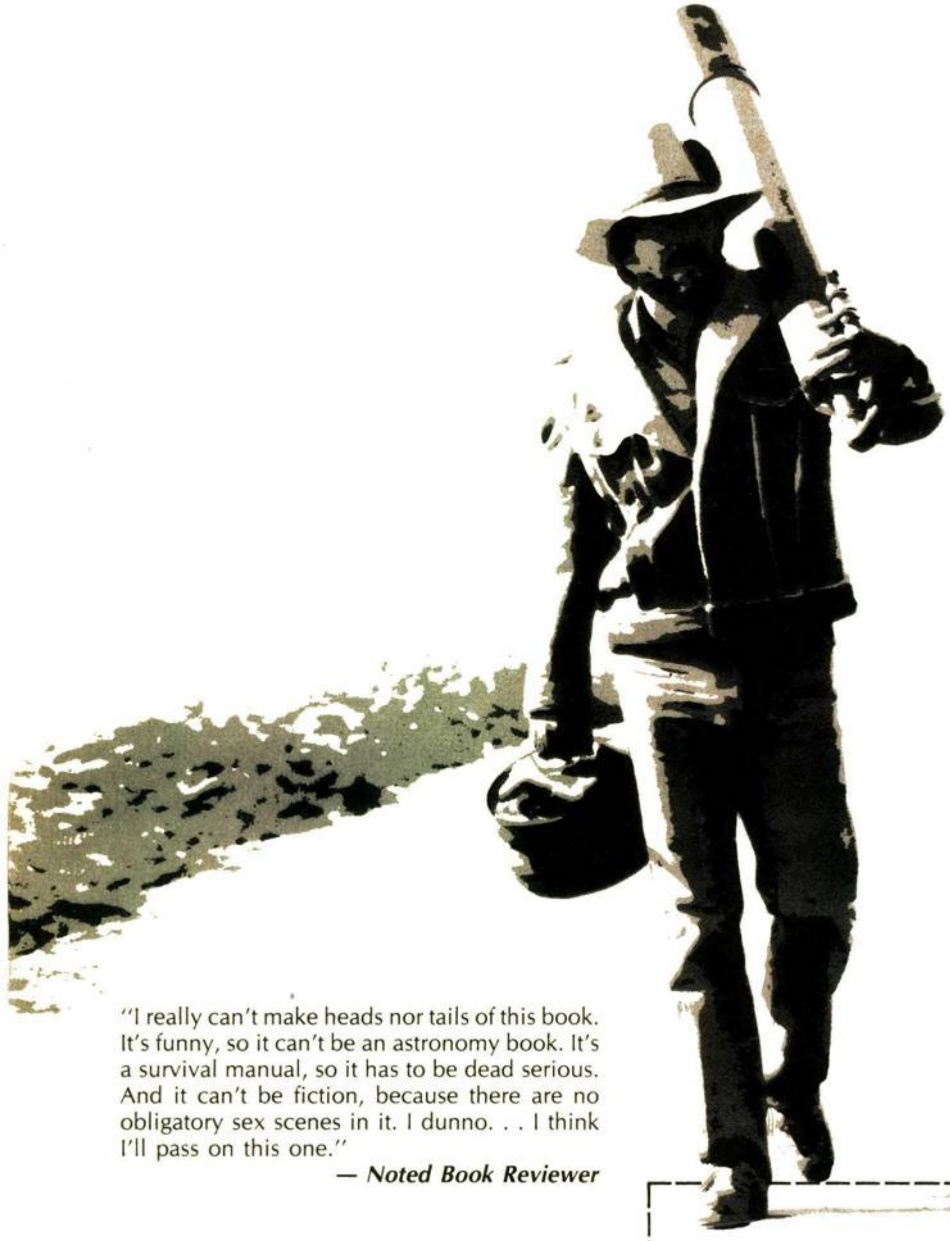
- R. Reinhard, a Giotto project scientist at the European Space Research and Technology Centre, writes on exploring Halley's Comet from space. Spacecraft being sent to Comet Halley by Europe, the Soviet Union, Japan, and the United States have turned out to be entirely complementary. (NASA has redirected its International Sun-Earth Explorer satellite from its "halo" orbit between Earth and the Sun to Comet Giacobini-Zinner. After encountering this comet, it will coast

AstroMedia Presents:

The Light-Hearted Astronomer

by Ken Fulton

A Survival Manual for Amateur Astronomers



"I made a big mistake when I purchased my first telescope. How I wish Fulton would have written this book sooner!"

— ***Galileo***

"I was lost and near death in astronomy's jungle. **The Light-Hearted Astronomer** saved me. As a token of my gratitude, I am sending Ken Fulton twelve billion dollars, four of my seventy-three wives, and sixty-three camels. If he doesn't smoke, he may return the cigarettes — but the wives stay."

— ***A. Sheik***

"Fulton has done astronomy an invaluable service. I think a lunar crater should be named after him."

— ***Plato***

"Look . . . my husband eats, drinks, and sleeps astronomy while I work my fingers to the bone keeping our household afloat. He loves astronomy so much that he'll probably spend what money he makes off this book to buy another eyepiece or something, even though I badly need a new mop. And you want me to write something praiseworthy about this book? You've got to be kidding!"

— ***Doris Fulton, wife of the author***

"I really can't make heads nor tails of this book. It's funny, so it can't be an astronomy book. It's a survival manual, so it has to be dead serious. And it can't be fiction, because there are no obligatory sex scenes in it. I dunno. . . I think I'll pass on this one."

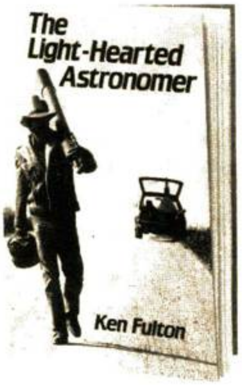
— ***Noted Book Reviewer***

The Light-Hearted Astronomer

$6.95

128 pages, paperback,
5½" x 8½"

Foreign orders add $1.50



☐ **Yep,**
I gotta have me a copy!
Here's my $6.95.

☐ **I want some for my friends.**
Send me ______________ copies, and
here's my check for $____________.

Name ______________________________

Address ____________________________

City ______________ State _______ Zip _______

Send this coupon or a copy to AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202, or use the handy order form bound into this magazine.

to a point between Comet Halley and the Sun where, now renamed ICE — International Comet Explorer — it will monitor the solar wind which will hit the comet somewhat later.) The two Soviet Vega spacecraft are three-axis stabilized, which helps imaging, while the other countries' spacecraft are spin-stabilized and more suited to plasma experiments. Reinhard says these spacecraft "provide the full complement of experiments that can be flown in a flyby mission."

- J. Fertig, F. Hechler, and G. Schwehm — all of the European Space Operations Centre's orbit attitude division — consider how we can navigate to a target hidden in dust — Comet Halley's nucleus, that is.

Once the comet has fallen far enough into the solar system for sunlight to evaporate its ice, gas and dust are released to create the coma. The nucleus will then be hidden from terrestrial view and its exact position is unlikely to be known to any better than 500 kilometers. If astronomers could rely on the nucleus to follow a simple gravitational orbit, the orbit would be perfectly calculable. Unfortunately, the outgassing which produces both coma and tail also produces a rocket-like effect that pushes the comet off its predicted orbit, varying its overall orbital period by as much as four days.

Because of this, mission analysis predicts a 40% chance of missing the target by more than 500 kilometers, which could cause an undesirable flyby on the dark side of the nucleus. As if this were not bad enough, the spacecraft will also have to traverse 50,000 to 100,000 kilometers of dust on its way to the nucleus. At Giotto's 68 kilometer-per-second flyby velocity, the impact of a particle weighing a tenth of a gram or more on the outer rim of the spacecraft's dust shield would knock the spacecraft's spin axis askew by more than 2° — causing loss of radio contact with Earth.

These are clearly major problems. One solution is to develop precise models of the comet's dust and gas envelope, and that envelope's influence on the motion of the comet's nucleus through space. But such models are far from easy to produce. Some problems include the lack of previous "on-site" measurements, the patchy emission of gas and dust from the nucleus, and the varying behavior of different-sized particles.

Current models show that the ground link will almost certainly be lost during closest approach, which would doom all subsequent data. But this may be overly pessimistic, because the probability of encountering any particle heavier than a tenth of a gram along the trajectory is less than 2% — assuming a homogeneously emitting nucleus. In reality, the probability of spacecraft survival will depend greatly on whether the probe will traverse jets or regions of low particle densities.

- R.E. Munch, also of ESOC's orbit attitude division, offers another possible solution — terminal navigation. Navigation for Giotto should be more than adequate with existing European ground stations and the new European deep space stations. Together, they should track the spacecraft's position at encounter to within some 100 kilometers. So once again, the problem boils down to pinpointing the nucleus' position.

Coincidentally, the Soviet Vega spacecraft are scheduled to fly past Halley a few days before Giotto's expected arrival, so the Soviets should thus have pictures of the nucleus against the background of stars. But using these images to pinpoint the nucleus' position depends critically on knowing exactly where the spacecraft were when they took the photographs. Here, NASA's Deep Space Network is ideally suited to making such measurements using very long baseline interferometry.

With international cooperation — Soviet Vega spacecraft data, a Hungarian camera for pointing angles, improved Vega positional data from NASA's Deep Space Network — the Europeans can guide Giotto to a successful encounter with positional accuracy on the order of 80 km. *Donald F. Robertson*

New Gravitational Lens Identified

A new "gravitational lens" has been uncovered during a survey of galaxy distances. Astronomers at the Harvard-Smithsonian Center for Astrophysics, using both conventional telescopes and the Multiple Mirror Telescope, identified the lens system as a 15th magnitude spiral galaxy in Pegasus.

The new lens system (designated 2237+0305) is the closest one to Earth yet found (see "Gravity Lenses," ASTRONOMY, July 1981). At 120 megaparsecs' distance, the lens is only one-tenth as far away as previous examples — which will allow opportunity for detailed studies of its structure and properties.

The lens was discovered by observer Edward Horine in September 1984 during routine spectrographic observations, part of a survey to determine distances of galaxies in the northern celestial hemisphere. The combined galaxy and quasar showed an anomalous spectrum, which prompted additional observations by John Huchra and Graeme Smith using the 4.5-meter Multiple Mirror Telescope and by Stephen Ken using a 24-inch telescope. Their observations confirmed that a previously-unidentified quasar seemed to be located only 0.3" from the galaxy's nucleus.

Courtesy J. Huchra, CfA.

Subsequent observations by Richard Perley at the Very Large Array radio telescope in Socorro, New Mexico, detected no radio emission from the lens system. Preliminary studies also found no X-ray or other high-energy radiation associated with the source.

The initial optical observations show a single image. However, a tightly-grouped cluster of images could exist at a resolution level beyond current observing capabilities. Larger ground-based instruments or the Space Telescope may resolve additional components.

Spacelab: The Physiological Challenges

The Voyagers and other space probes have repeatedly shown that instruments can take it — decade-long lifetimes in space are routine for them. But what about humans? How long could you last on a two-year weightless trip to Mars or even a long stay in Earth orbit? And what would be your life expectancy when you came back? More than questions of funding, physiological challenges may pose the most significant threat to long-duration space missions. Not surprisingly, mission planners gave great priority to life science experiments aboard the Spacelab 1 mission in November 1983.

Their research focused on the causes of space sickness and cures for its debilitating effects. (See also AstroNews, February 1985.)

A complex malaise, space sickness consists of a number of distinct, but related ailments including nausea and vomiting, alterations to bone marrow, calcium loss, lowered red-corpuscle counts, body fluid shifts and a host of large and small ills peculiar to working in weightlessness.

Mission and payload specialists underwent intensive medical examination before, during, and after the flight. The eye's role in body orientation and the coupling of eye motions to the inner ear system were studied in detail. Techniques measured how the organs and semicircular canals of the inner ear related to eye movements, perception, orientation, bodily posture, and susceptibility to motion sickness — which varies enormously among individuals.

In weightless conditions, the eyes provide your brain with information on the body's equilibrium. Meanwhile, your normal balancing organs — made useless under weightlessness — are busy sending signals which don't agree with your eyes. After a few days, it was found that an ocular reflex called nystagmus — a rapid involuntary rotation of the eyes, usually leading to dizziness and unconsciousness — could be provoked.

Unfortunately, pre-flight physiological studies carried out aboard the aptly-nicknamed "vomit comet" — a KC-135 aircraft which flies a steep parabolic curve to give less than a minute of weightlessness — seem to be measurably inaccurate when compared with Spacelab data. At this point, there is serious question how much physiological knowledge derived from KC-135 flights will actually carry over into spaceflight.

Several other important biological studies were carried out — one looked at lymphocyte reproduction following injections of an antigen to discover how weightlessness affects the body's ability to ward off disease. Pre-flight, in-flight, and post-flight blood samples from crew members were analyzed for changes in the levels of disease-inhibiting immunoglobulins.

They found that weightlessness may weaken the lymphatic activation process, thus lowering one's immunoglobulin level and subsequently the body's resistance to infection. Further research is needed to pinpoint these biochemical difficulties.

The volume of blood that your system circulates decreases during space flight; this may be due to inhibition of the bone marrow (where red corpuscles are produced). Past manned American and Soviet space flights have shown

WHEN YOU TURN TO THE SKIES — TURN TO YOUR ASTRONOMICAL FRIEND: ROGER W. TUTHILL

PRECISION POLAR AXIS FINDER

(USA Patent #4,260,253.) Get perfect celestial polar alignment quickly and easily every time without leveling your tripod. When the centered 4x crosshairs are set on Polaris the built-in 0.8 degree offset barrel points directly and precisely to the pole. Novel Polaris date and time chart supplied FREE. Now available with FREE Ring-o-Fire glowing crosshairs for easy viewing. Also available for most other scopes.

CALL TOLL-FREE:

1-800-223-1063

FOR INFO ON TUTHILL CUSTOM-ENGINEERED ACCESSORIES FOR ALL TELESCOPES:

- Huge 50mm & 80mm Diameter Right-Angle Finders
- Rock-Steady Isostatic Equatorial Mount
- Unique Stereoocular Viewer for 1¼″ eyepieces
- Accurate Space-Age Celestial Navigator Digital Displays
- Heated NO DU Caps for less frustration from dewing.
- Easy to Install Manual R.A. Slow Motion Micro Drive

Recognized as Headquarters For Telescope Solar Filters Solar-Skreen® Sun Filter

SOLAR-SKREEN® Sun filters (USA Patent #3,897,140) fit all scopes and use no glue or magnets. Double aluminum surfaces are shielded from damage. The fine qualities and SAFETY of this filter are described in detail by Dr. B.R. Chou in *Sky and Tel.* pg. 119, August 1981, and *Astronomy* Review, March, 1982 pg. 75.

We also have a full line of Light Pollution Filters as well as Hydrogen Alpha Filters. In addition, we sell Clave, TeleVue and Celestron Plossl Eyepieces as well as other astronomical accessories.

Send a large (9″ x 12″ — 3 oz.) MANILA Self-Addressed Stamped Envelope for our Complete Information Kit including "Tuthill's Twenty-Two Telescope Tips."

Interested in a Schmidt Cass scope? We urge you to get a CELESTRON® **EVEN** if you don't get it from us. You will be a lot happier with the optical perfection and proven performance.

WE REPAIR **CELESTRON** SCOPES

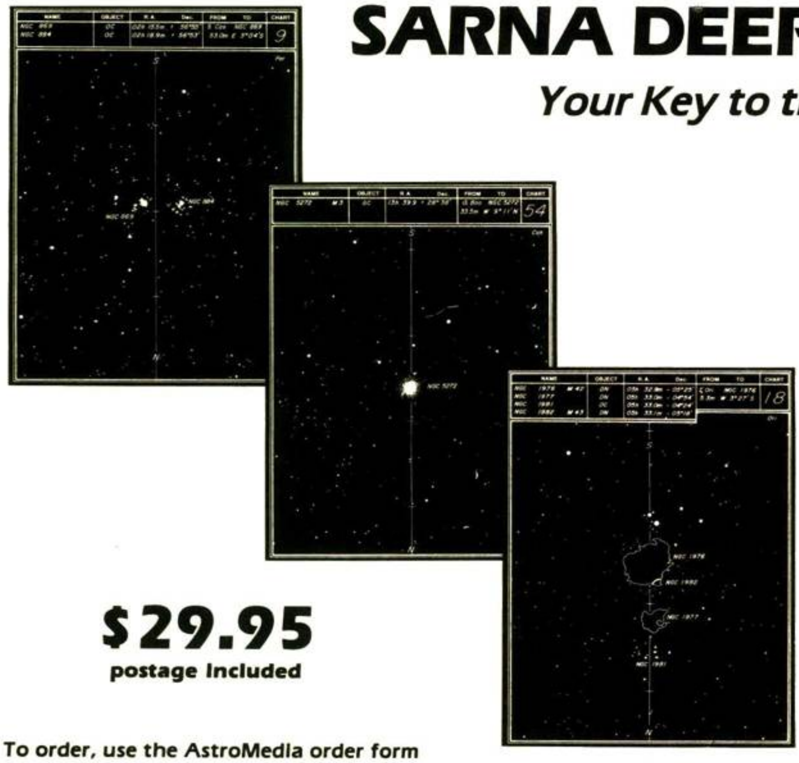
MasterCharge, VISA *Trademark

ROGER W. TUTHILL, INC.

Telephone: (201) 232-1786
11 Tanglewood Lane, Dept. A, Mountainside, N.J. 07092

SARNA DEEP SKY ATLAS

Your Key to the Deep-Sky Universe!



The **Sarna Deep Sky Atlas** was created by Tom Sarna, an experienced deep-sky observer who wanted to make finding galaxies, clusters, and nebulae easy.

Its 102 charts show you the star patterns surrounding 255 deep-sky objects down to −40° declination (including all the Messier objects), and provide step-by-step directions on how to get there from bright, easy-to-find guidepost stars.

Included with the charts are a poster-size finder map, showing the charts' positions on the sky, and complete instructions.

With the Sarna Atlas, you'll be an expert deep-sky observer in no time!

- **102 charts, each 8½″ x 11″**
- **Plots locations of 255 deep-sky objects**
- **Includes finder map and instructions for use**
- **Printed on heavy-weight stock with white stars on handsome midnight blue background**
- **Shrink-wrapped in protective plastic**

$29.95
postage included

To order, use the AstroMedia order form bound into this magazine, or send to AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

ASTRO NEWS

significant post-flight reduction in the mass of circulating blood cells. How this happens is still unknown, but on short missions no lasting damage occurs. On longer missions, the outcome is not so clear. Many factors remain to be analyzed including the concentration of salt and water in the body, the effects of anti-motion sickness drugs (the standard motion sickness drugs scopolamine and dexedrine were used on the Spacelab 1 mission), and the body's natural day-night rhythms.

Photos of many crew members taken in flight show a distinct puffiness in their faces, resulting from a shift in body fluids from the lower limbs toward the head. Spacelab astronauts conducted experiments to see if this would lead to permanent increases in blood pressure in the upper torso. The fluid shift occurs three to six hours after launch. An hour after landing, the redistribution of fluids stored somewhere in the upper body was fully under way. Important questions on cardiovascular physiology still remain unanswered — for example, where is the fluid stored and why does it accumulate in the upper body?

Even though Spacelab 1 answered a number of baffling questions, almost as many were created. It is essential that life science flights be continued to answer these remaining questions. *Aldo Rabaiotti*

ASTRO CALENDAR

March 2
ASTROPHOTO VI Seminar, California State University, Fullerton, California. Sponsored by the Orange County Astronomers, Ventura County Astronomical Society, and the Physics Club of California State-Fullerton. Contact: John Sanford, ASTROPHOTO VI Coordinator, 2215 Martha Ave., Orange, CA 92667. Phone (714) 639-8446.

March 29-30
The Wisconsin Society of Science Teachers Annual Spring Convention, Madison, Wisconsin. Contact: Bruce G. Smith, WSST, 1017 E. Lindbergh St., Appleton, WI 54911.

March 31-April 3
Softcon (the International Conference and Trade Fair for Software Merchandisers, Publishers, and Corporate and Institutional Users), Georgia World Congress Center, Atlanta, Georgia. Contact: Softcon, c/o Northeast Expositions, 822 Boylston St., Chestnut Hill, MA 02167. Phone (617) 739-2000.

April 11
Third Annual Space Awareness Day, Commerce, Texas. Hosted by the East Texas State University Science Fact-Science Fiction Society. Contact: Dr. John Lamb, Jr., 2812 McCarley, Commerce, TX 75428.

April 12-13
1985 Southwestern Association of Planetariums Conference, Fort Worth, Texas. Contact: Michael P. Walker, Planetarium Specialist, Noble Planetarium, Fort Worth Museum of Science and History, 1501 Montgomery St., Fort Worth, TX 76107. Phone (817) 732-1631, ext. 409.

Meeting notices to appear in AstroCalendar must be submitted at least four months in advance of the meeting date. Most organizations appreciate your enclosing a long (business-size) self-addressed, stamped envelope along with your request for information.

April 18-21
National Convention of the National Science Teachers Association, Cincinnati, Ohio. Contact: NSTA, 1742 Connecticut Ave. N.W., Washington, DC 20009.

April 20
39th Annual Convention of the North Central Region of the Astronomical League, Fermi National Accelerator Laboratory, Batavia, Illinois. Sponsored by the Naperville Astronomical Association. Contact: Deena R. Joslin, 1985 NCRAL Convention Chairman, 959 W. Ogden Ave., Naperville, IL 60540. Phone (312) 355-5357.

April 27
Astronomy Day. For more information, contact: Gary Tomlinson, Astronomy Day Coordinator, Chaffee Planetarium, 54 Jefferson S.E., Grand Rapids, MI 49503. Phone (616) 456-3985.

April 27-28
Abell Memorial Weekend (in memory of George Abell). Teacher's workshop and public lecture series on new developments in astronomy. Jointly sponsored by the A.S.P. and U.C.L.A. Contact: Andrew Fraknoi, Abell Workshop, A.S.P., 1290 24th Ave., San Francisco, CA 94122. Phone (415) 661-8660.

May 15-19
Texas Star Party, Prude Ranch, Fort Davis, Texas. Contact: TSP '85, Dept. A, 128 N. Commerce, Burleson, TX 76028.

May 22-24
IAPPP Big Bear Symposium, Camp Oaks, Big Bear Lake, California (same location as Riverside Telescope Maker's Conference). Contact: Rev. Donald L. Rohe, 957 W. Marshall Blvd., San Bernardino, CA 92405. Phone (714) 383-4731 or (714) 883-7923.

May 24-27
Riverside Telescope Maker's Conference, Camp Oaks, Big Bear, California. Contact: Cliff Holmes, 8642 Wells Ave., Riverside, CA 92505. Phone (714) 689-6893.

May 25-29
Planetarium Association of Canada Biennial Conference, Toronto, Canada. Contact: Chris Sasaki, Conference Registrar, McLaughlin Planetarium, 100 Queen's Park Crescent, Toronto, Ontario, Canada M5S 2C6.

June 7-8
15th Annual Apollo Rendezvous and Telescope Fair, Dayton, Ohio. Sponsored by the Miami Valley Astronomical Society and the Dayton Museum of Natural History. Contact: Chairman, Apollo Rendezvous, P.O. Box 20268, Dabel Branch, Dayton, OH 45420.

June 9-12
Southeastern Planetarium Association Annual Conference (professional conference), Land Between the Lakes, Kentucky. Contact: Doug Gegen, Conference Coordinator, Visitor Center, Land Between the Lakes-TVA, Golden Pond, KY 42231. Phone (502) 924-5602.

June 17
3rd American Workshop on Cometary Astronomy, Tucson, Arizona. Contact: Steve Edberg, Jet Propulsion Laboratory, 4800 Oak Grove Dr., MST 1166, Pasadena, CA 91109.

June 17-22
ALCON '85, Tucson, Arizona. Contact: Shelley Fleischman, c/o Venture Travel Inc., 6709 E. Camino Principal, Tucson, AZ 85715.

June 23-27
Astronomical Society of the Pacific Meeting, Flagstaff, Arizona. Contact: Andrew Fraknoi, A.S.P., 1290 - 24th Ave., San Francisco, CA 94122. Phone (415) 661-8660.

ASTROMART

AstroMart listings are free to all our readers for non-commercial purposes — but only 2 per person per year, please. Limit your ad to 40 words including your name and address and allow 4 to 6 months for it to appear. All ads are subject to review for suitability. AstroMedia assumes no responsibility for statements made in classified ads, nor for the quality of advertised items.

ANNOUNCEMENT — The South Alabama Amateur Astronomical Society invites all astronomy enthusiasts in southern Alabama to join their growing membership. Activities include star parties, films, lectures, and informational materials. Contact D.L. Parrott, Route 2, Box 169-B, Grand Bay, AL 36541.

ANNOUNCEMENT — First Annual Messier Marathon and Star Party is to be held March 23 and 24 at Pax's Park & Campground in Cadiz, California. Sponsored by the South Bay Astronomy Club. Contact Ralph Ford, 1809 Walnut Ave., Manhattan Beach, CA 90266.

FOR SALE — Dynamax 8, special coatings, Golden Pyramid tripod, Celestron wedge with latitude adjuster, four eyepieces (40mm, 30mm, 18mm, and 12.5mm), drive corrector, and more. Contact Russ McDonald, 7520 Merriman Rd., Apt. 102, Westland, MI 48185. Phone (313) 525-8531.

FOR SALE — 12x40 binoculars, super high-quality optics, make offer. ASTRONOMY back issues, 1983-1984 complete, excellent condition, $24 plus shipping. *Deep Sky* back issues, #4-#8, $11. Contact Michael Keylin, 4600 9th Ave., #602, Brooklyn, NY 11220. Phone (212) 633-5871.

FOR SALE — Astronomy-related books and magazines. Send stamped, self-addressed envelope for description and prices to Dr. Richard A. Muntean, 748 E. Lucius Ave., Youngstown, OH 44502.

FOR SALE — Meade 2080, coatings, wedge, tripod, and accessories, $900; counterweight system, $50; six Tele Vue Plossls in case, $300; 2" star diagonal with 55mm Tele Vue Plossl, $285. Contact Ron Adams, 213 Timberlane, Marquette, MI 49855. Phone (906) 249-9552 evenings.

FOR SALE — ASTRONOMY Magazine, 1980 through 1984 complete, all with binders; *Sky & Telescope*, 1982 through 1984 complete, 2 binders. Will sell all or as yearly sets. Best offer gets them (include postage in your quote). Contact Jeff Gross, 2316 Ducoma Dr. N.W., Grand Rapids, MI 49504.

FOR SALE — 4" Bausch & Lomb Criterion 4000 telescope, two eyepieces, star diagonal, coatings, clock drive, finderscope, tripod, case, visual back. $425 plus shipping/insurance. Contact Tony DiSciullo, Box 2097, Aston, PA 19014.

FOR SALE — 10" f/6 Dobsonian telescope with Meade components, including 6x30 R.A. finder, 680 focuser, spider, and mirrors. Excellent condition. Best offer, delivery negotiable. Contact Lance Giesbrecht, Route 2, Box 51, Macon, MS 39341. Phone (601) 726-2437.

FOR SALE — ASTRONOMY back issues, March 1978 to February 1982 (48 copies), excellent condition. $95 postpaid or best offer. Contact Larry Abraham, 3839 Sherman, Bridgeport, MI 48722.

FOR SALE — ASTRONOMY back issues, November 1979 through October 1982, excellent condition. Write with offer to J. Branicky, 4083 S. Four Mile Run Dr., #204, Arlington, VA 22204.

ADVERTISER LISTING

ADVERTISER **PAGE**

Ad-Libs Astronomics . . . 23
Astro Cards . . . 71
Astroline Products . . . 71
Barnes & Noble . . . 41
Birkhauser Boston Inc. . . . 73
Bushnell . . . 30
Calif. Telescope Co. . . . 48
Celestron Intern'l. . . . 59,74,86-87,88
Comet News Service . . . 65
Cosmic Connections, Inc. . . . 73
Coulter Optical . . . 55
Equapolar Tours . . . 65
Focus Camera . . . 31
Fujinon . . . 65
Lumicon . . . 50
Meade Instruments . . . 2-3
Meteorites . . . 72
Mibro Co., Inc. . . . 71
Microtechnic Solutions . . . 48
New England Astro-Optics . . . 72
Northeast Instruments . . . 65
Optics Ohio . . . 73
Orion Telescope Center . . . 27
Pauli's Optic . . . 71
Quasar Optics . . . 73
Rainbow Adventure Holidays . . . 72
Scope City (Tomlin) . . . 72
Sky Instruments . . . 73
Star Tracker . . . 72
TeleVue . . . 58
Texas Nautical . . . 72
Tuthill, Roger W. . . . 63

HALLEY'S COMET-NEW ZEALAND
Long Term Stays - Feb.-May '86
Short Term Stay - Mar.-Apr. '86
EQUAPOLAR TOURS
BOX 1471 • LAWRENCE, KS 66044
PHONE (913) 842-1009

Comet / NEWS SERVICE
Publisher: St. Louis Science Center. Editor: J. N. Marcus

A leading international quarterly on comets. Timely special issues for bright comets. Subscribe now at these economical rates and follow **Halley's** through our pages.

SUBSCRIPTIONS

US & Canada (1st cl)	$5.00/yr	$10.00/2 yr
Other countries (air)	$7.50/yr	$15.00/2 yr

P.O. Box TDR No. 92, Truckee, CA 95734
702-851-4151

Sidereal Clock **$29.95**
plus $3.00 shipping

12:09
Sidereal Time
Northeast Instruments

- six month warranty
- continuously updated
- runs on 110-120 volt AC, 60 cycle current
- cumulative error is 1.89 seconds per year

30 day return privilege if not satisfied.

Send personal check or money order to:
Northeast Instruments
P.O. Box 14764
Minneapolis, MN 55414

Fujinon's NEW 25 × 150mm Right Angle Astro Binocular

Don't miss Halley's in '85.

The world's most powerful and the first right angle binocular made for astronomical observation.

Fujinon—first name in broadcast tv lenses, laser and holography optics and advanced binoculars—announces the most powerful astro binoculars made. Allows 90° observations with greater viewing comfort. Electron beam coated, computer-designed optics for unmatched brightness, clarity and freedom from flare. Totally waterproof, supplied with tripod, calibrated 0°-90° elevation control and 360° azimuth, carrying case. Protected by a lifetime warranty against manufacturing and material defects.

Specifications

Exit pupil	6mm ± 5%
Relative brightness	36
Field of view—	
Apparent	67.5°
Real	2.7°

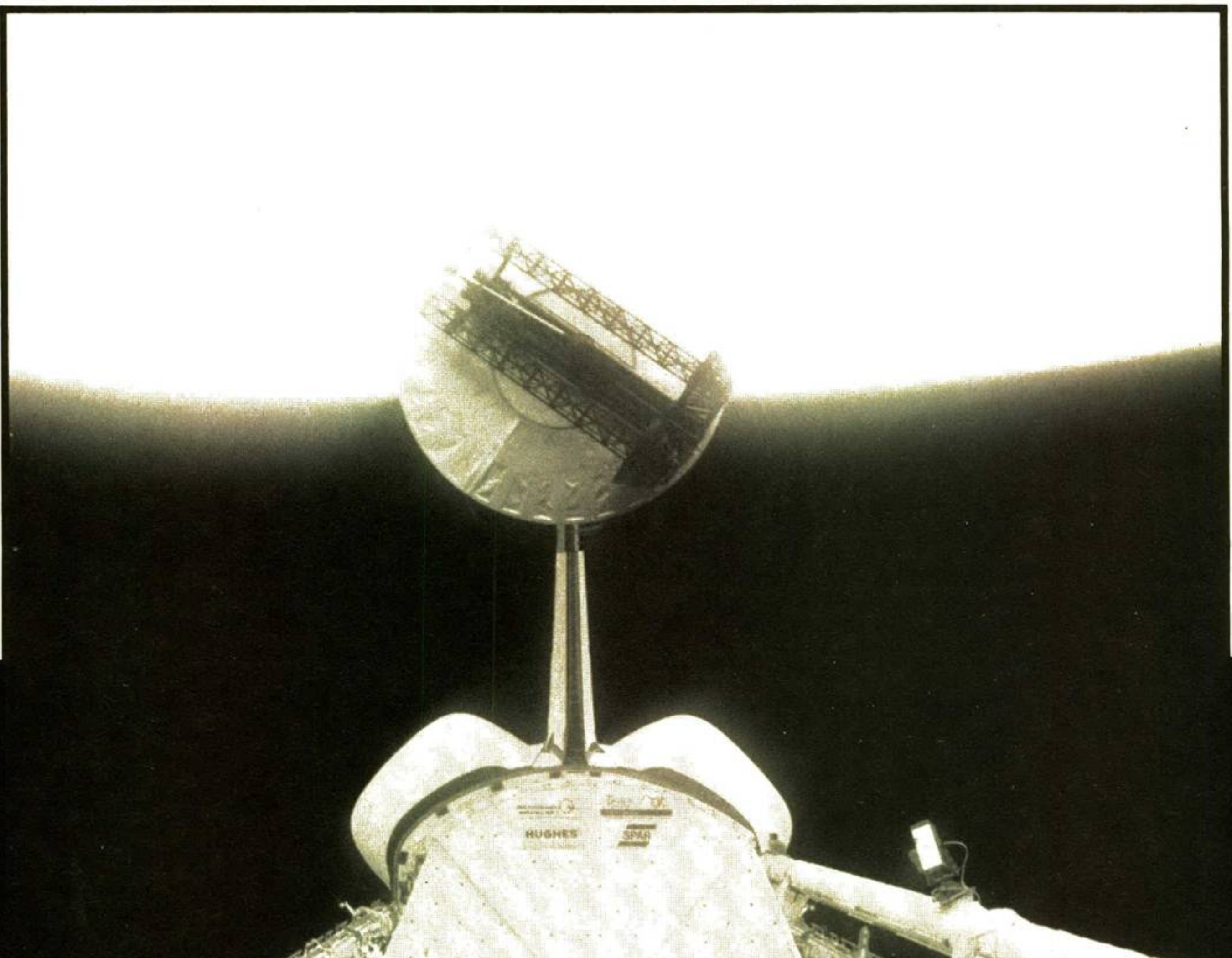
FUJINON

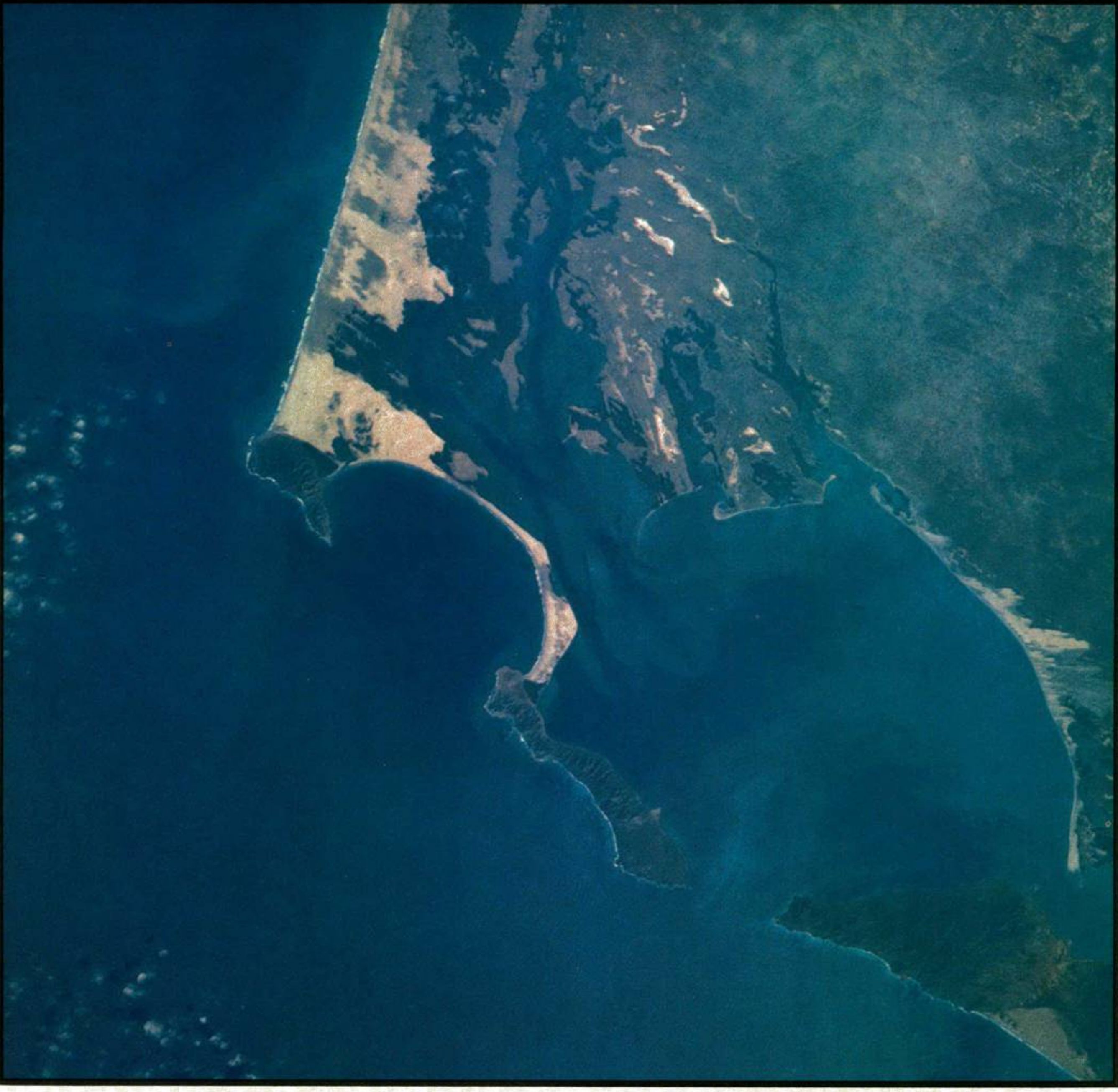
Dealer Inquiries Invited

FUJINON INC.
672 White Plains Road
Scarsdale, New York 10583
(914) 472-9800
Write for free full color catalog.

Earth, Water, Sky

The 14th Flight of the Shuttle

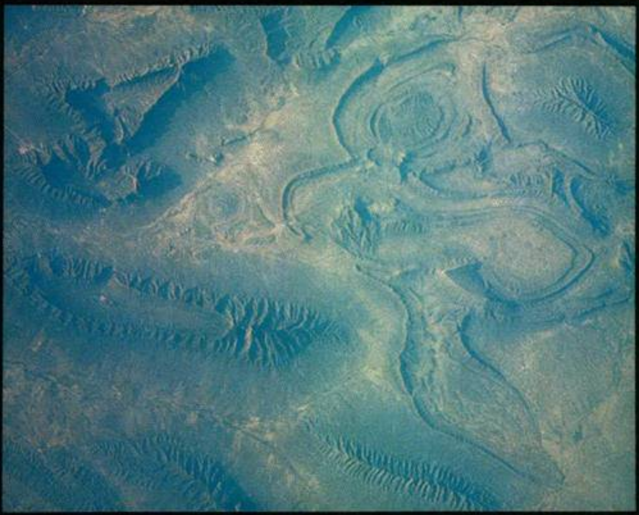

HUGHES
SPAR

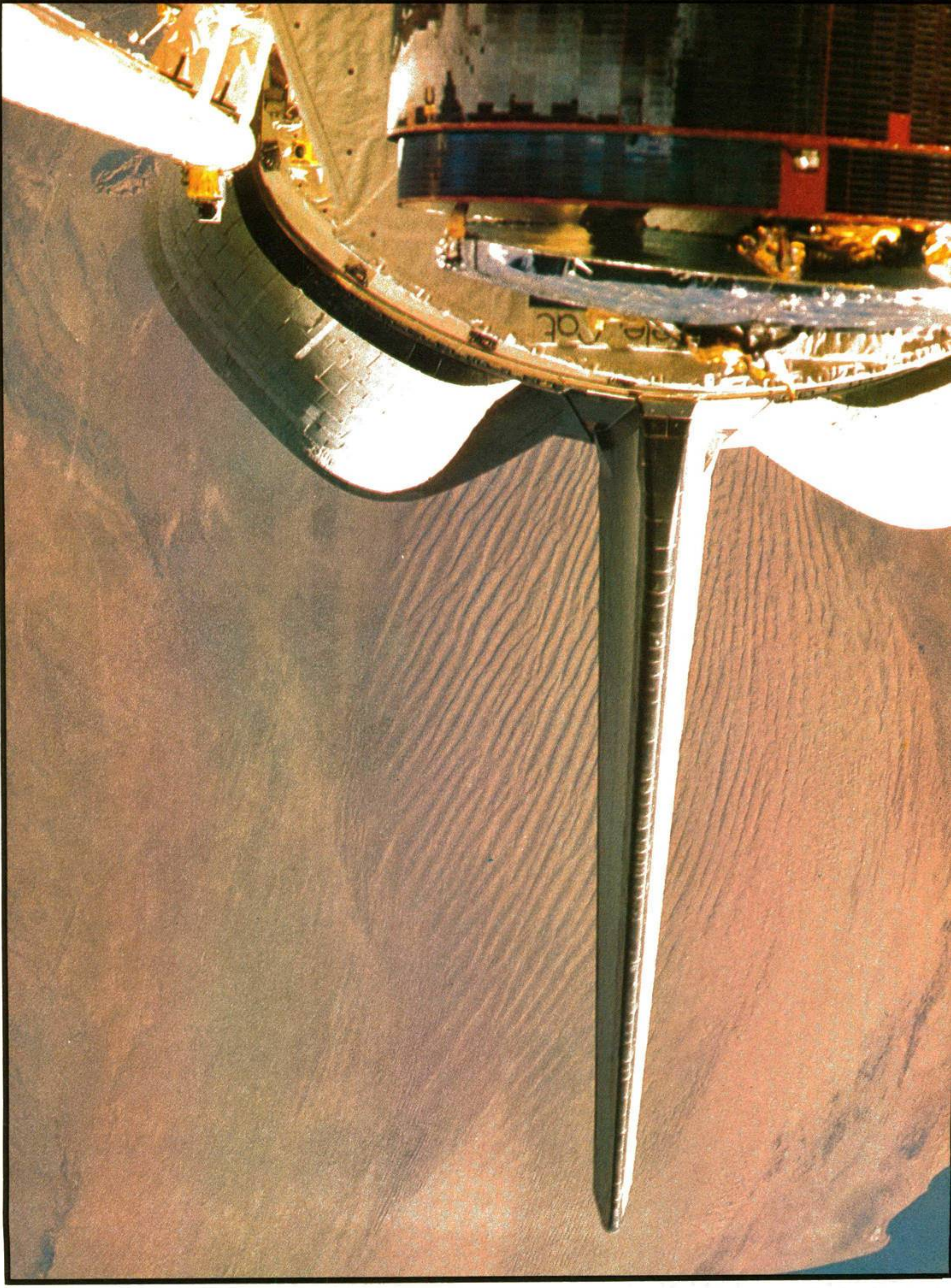


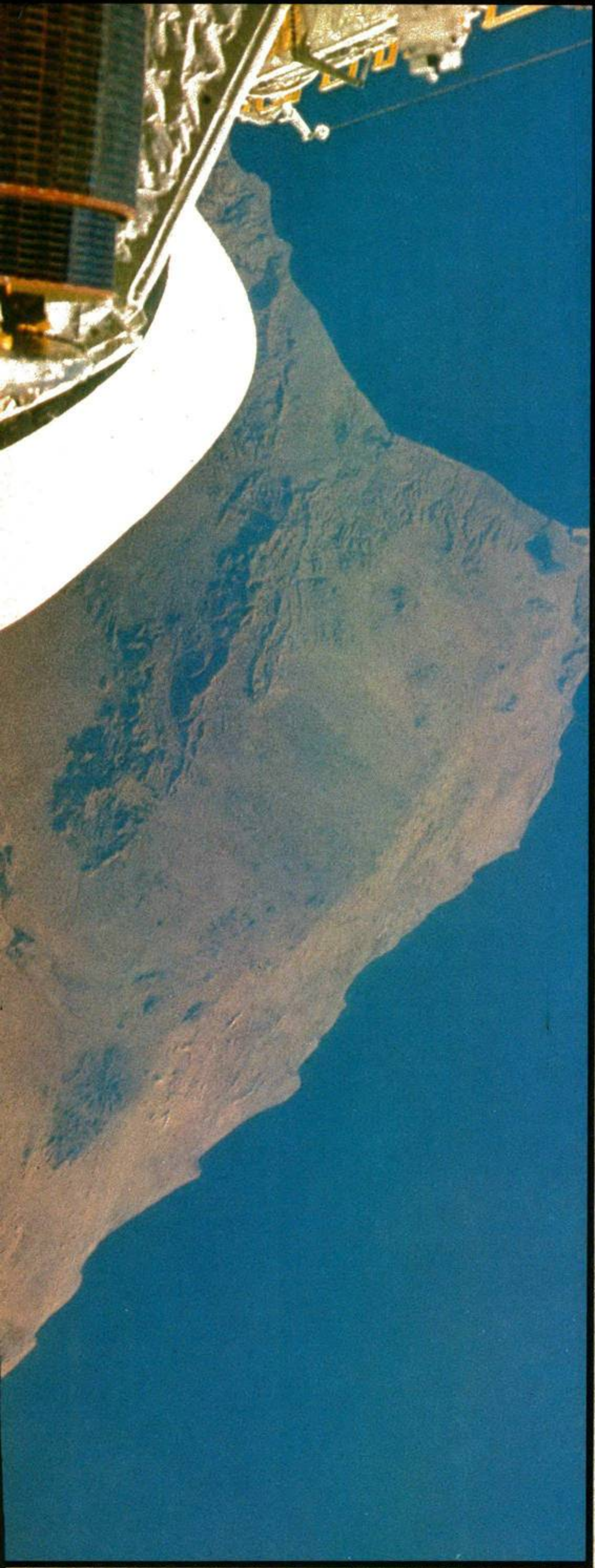
Left: With a cloud-flecked Earth hovering above, Syncom IV-1 (the second of the Shuttle's two cargo deliveries) is kicked out of the payload bay and sent to work. The next task awaiting the crew of the 14th Shuttle mission: snare two errant communications satellites and bring them back intact (frame S19-34-074; all photos from NASA).

Above: Magdalena Bay on the southwest coast of Baja California is a mating ground for grey whales (frame S19-45-011).

Right: A low-angle Sun illuminates the rugged topography of Mexico's Sierra Madre Oriental (frame S19-36-055).



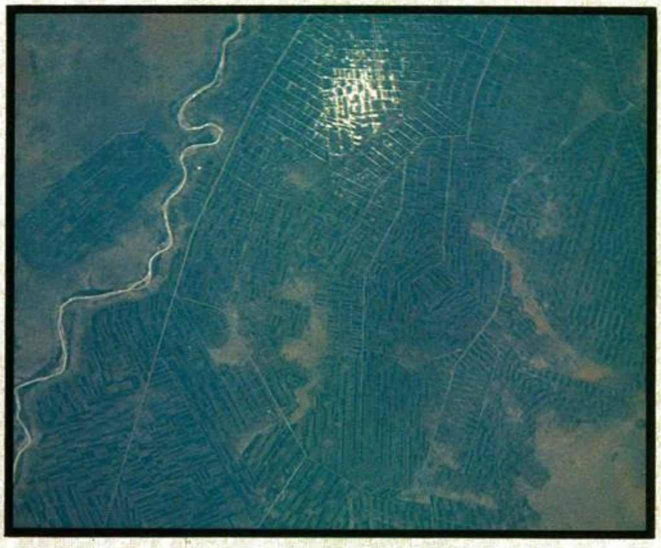


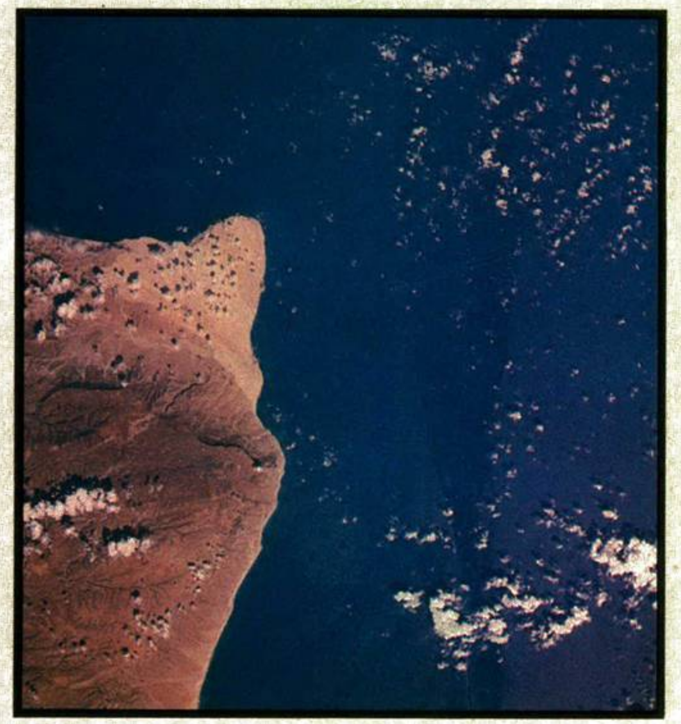


Left: Enormous sand dunes in Oman streak the ground behind Discovery's tail fin. In its cargo bay rests the recovered Palapa B-2 satellite (frame S19-41-106).

Below: Sudanese cotton irrigation canals gleam with sunlight; the region, El Gezira, lies south of Khartoum between the White and Blue Nile Rivers (frame S19-34-012).

Bottom: Ras Azir, the Horn of Africa (frame S19-45-085).

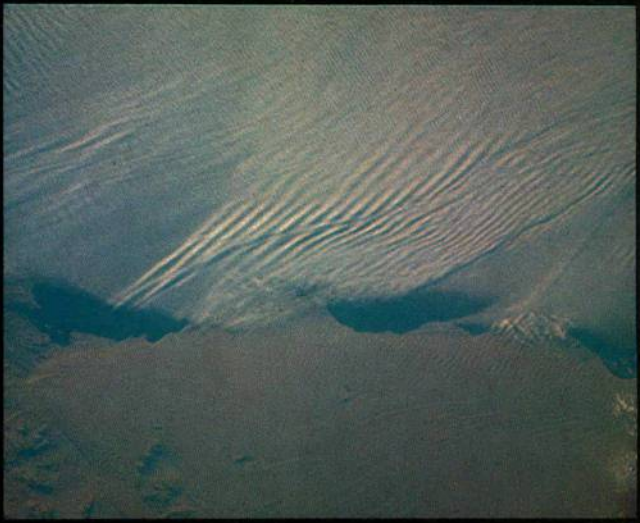


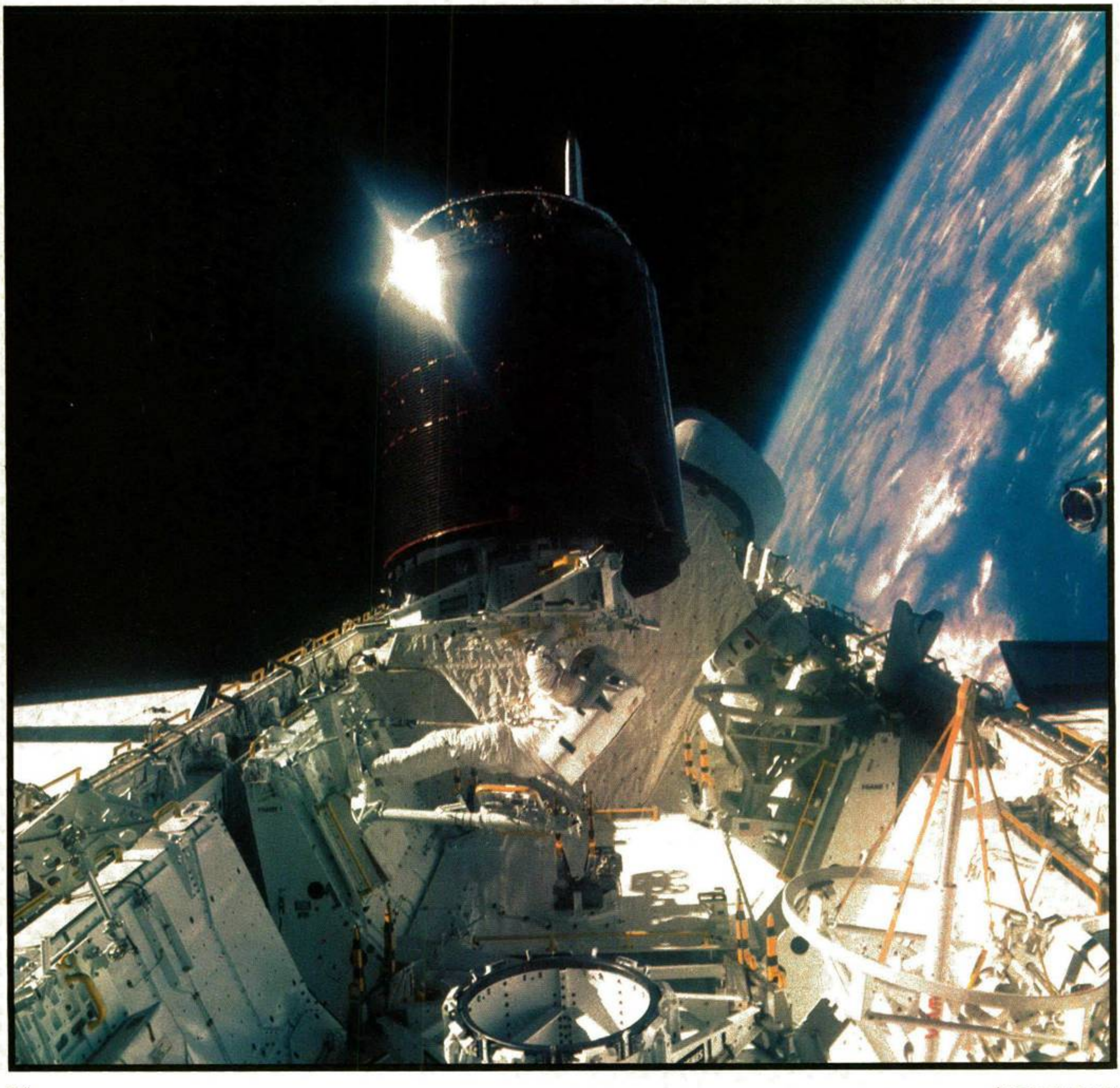


Below: Astronaut Dale Gardner (left) holds Palapa B-2, the first of the two satellites recovered; Joseph Allen is at right (frame S19-41-063).

Right: The lower half of the photo shows sand dunes in the Namibian desert, while in the top half, fog blankets the Atlantic Ocean. Rainfall in the area amounts to only a few inches per century (frame S19-35-101).

Note: NASA photos are available to the general public through Space Photographics, P.O. Box 486, Bladensburg, MD 20710. Write for their price list, stating the frame number(s) you are interested in.





ASTROMART

FOR SALE — Back issues of ASTRONOMY, 1976-1980, mint condition. $120 for entire collection. Contact John J. Campbell, 776 Holly St., New Milford, NJ 07646.

FOR SALE — Dynamax 8, one year old, excellent condition. Includes lateral adjustment legs, carry case, manual, and three eyepieces (7mm, 18mm, and 30mm orthos). Am selling to purchase bigger scope. $700 plus shipping. Contact Joe Fusco, 1704 Wembley Dr., Wilmington, DE 19809. Phone (302) 792-0349.

FOR SALE — Meade 645 6″ f/5 reflector with equatorial mount, motor, 8x50 finderscope plus extras, in excellent condition. $425. Will deliver in New York tri-state area. Contact Ray Schiller, phone (201) 461-2441 evenings.

FOR SALE — Back issues of ASTRONOMY, most issues from 1974 to present. Back issues of *Sky & Telescope* since 1950. $2.00 each postpaid (U.S. only). Contact Astro. Society, c/o Charles Scovil, Stamford Observatory, 39 Scofieldtown Rd., Stamford, CT 06903.

FOR SALE — Celestron 5.5″ Schmidt camera, unused, $600 or best offer; Celestron Erfle eyepieces, unused, 20mm-32mm, $30 each or best offer; 2″ 18mm ortho, $45 or best offer. Contact Paul Sterngold, Ford Country Day School, Stonebrook Ct., Los Altos Hills, CA 94022. Phone (415) 948-4752 days, (408) 739-9296 evenings.

FOR SALE — ASTRONOMY back issues in file folders, August 1973 to present, mint condition. $270 plus U.P.S. Contact Chas. H. Heltzel, 5025 S.W. Humphrey Park Crest, Portland, OR 97221. Phone (503) 292-8485.

FOR SALE — Astroscan 2001 RFT, $145; University Optics 11x80 binoculars, $135. Complete accessories, both in excellent condition. Savings for pick-up. Contact Jim O'Donnell, 13 Twin Lights Ct., Highlands, NJ 07732. Phone (201) 291-1598.

FOR SALE — Meade 16″ Newtonian with clock drive, S.M. declination, 6″ setting circles, 8x50 finder, 25mm Kellner eyepiece, two years old. $1450. Contact Don Pray, 40 Hillcrest Dr., Cranston, RI 02920. Phone (401) 946-0561.

FOR SALE — Celestron 1¼″ Plossl oculars (26mm, 15mm, and 10mm), almost new. All three for $125. Contact Dan Smith, 7234 Hardwicke Pl., Dayton, OH 45414.

FOR SALE — Celestron 8″ SCT, standard equipment, special coating, wedge, and tripod. Extras include Rich-field f/5 adapter, dew cap, and Timex 16k computer scope. In good shape, $750. Contact John Messer, P.O. Box 14, Petoskey, MI 49770. Phone (616) 539-8278.

FOR SALE — Criterion RV-6 Dynascope; includes three eyepieces, Barlow, equatorial mount, clock drive, and finderscope; excellent condition, $225. Also back issues of ASTRONOMY, July 1974 to present; $75. You pay freight. Contact John Sevores, 119310 German Gulch, Silver Bow, MT 59750.

FOR SALE — 6″ Edmund reflector with heavy-duty equatorial mount, clock drive, three eyepieces, and barlow. Excellent condition, best offer. Contact Henry Cancienne, Route One, 209 Bellevue, Lockport, LA 70374. Phone (504) 532-2875.

FREE — Back issues of ASTRONOMY, August 1979 to present (three issues missing from 1982). You pay postage. Contact Larry Landolfi, 82 Richardson Ln., Islip, NY 11751.

FOR SALE — 1955 hardcover edition of H.C. King's *History of the Telescope*, $55; 1922 edition of Louis Bell's *The Telescope*, $55. Both in excellent condition. Contact Rodger W. Gordon, 637 Jacobsburg Rd., Nazareth, PA 18064. Phone (215) 759-6805 after 5 p.m.

It pays to advertise in ASTRONOMY!

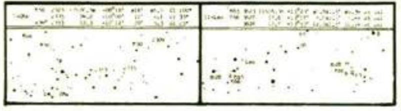
UP TO 50% DISCOUNT

Bausch & Lomb
Criterion

PAULI'S OPTIC
29 KINGSWOOD RD.
DANBURY, CT 06811
Tel: (203) 746-3579

Telescopes
Spotting Scopes
Binoculars
Catalogs $1.00

— TRADE-IN'S CONSIDERED —



INDEX CARD FINDER CHARTS

Made especially for use at the telescope!
75-handy 3x5 star-charts per set.

SET I - THE MESSIER OBJECTS.........$7.50
SET II - THE FINEST NGC OBJESTS.......$7.50
SET III - THE FINEST DOUBLE STARS.....$7.50
SET IV - THE FINEST NGC, Part B........$7.50

2 or more sets, $7.00 ea. 4 or more $6.50 ea.

NEW! OBSERVER'S LOGBOOK

For recording & drawing observations of planets, Sun, comets, deep-sky. 3-ring binder & 100 observing forms. Send for info. $16.95.

Send 37¢ stamp for FREE slide catalog. Outside USA add 20% extra for airmail postage.

ASTRO CARDS
P.O. Box 35, Natrona Heights, PA 15065

HALLEY'S COMET IS ON THE WAY! THE T-SHIRTS ARE HERE NOW!

Top quality silkscreen on navy blue shirt with beautiful multicolored comet ONLY $8.95

5 Designs as well as Hats, Trvl. Bags & Stickers
SEND FOR FREE CATALOG

SPECIFY STYLE #501 AND SIZE XL, L, M, SM & JR 10-12

Send $8.95 (PPD) to
ASTROLINE PRODUCTS
1925 Juan Tabo NE, Suite B248
Albuquerque, NM 87112

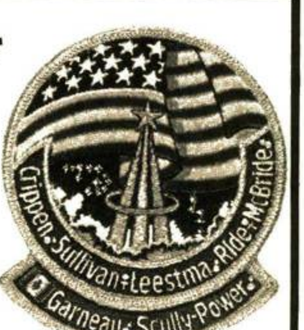
I'm Just Like Halley's Comet
A Once in a Lifetime Experience!

Add STS-41G to Your Emblem Collection

The 41G mission of the Space Shuttle *Challenger* is symbolized on this multi-colored embroidered emblem with NASA's official design. The mission features a spacewalk by the first American woman, the first flight of a Canadian astronaut and the deployment of the Earth Radiation Budget Satellite.

STS-41G 4″ x 4¾″ $4.95

To order, use the AstroMedia order form bound into this magazine, or send to AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202.



MIBRO CO., INC.
EST. 1950

OUR ONLY STORE

CAMERA DISCOUNTS ON ALL YOUR PHOTOGRAPHIC NEEDS

MIBRO CO., INC.
1595 BROADWAY
(BETWEEN 48th & 49th STREETS)
NEW YORK CITY, NEW YORK 10019
MONDAY THRU SATURDAY 9 AM — 9 PM
SUNDAY 11 AM — 8 PM

Meade
97D/3.5″ SPOTTING SCOPE
INCLUDES: Diagonal Prism • 2 Eye Pcs • Tripod • Adapter
$299

Meade 87D/3.1″	$219
Meade 107D/4″	$369
Meade 2044/4″ Schmidt-Cassegrain	$599

ALL ACCESSORIES IN STOCK

Meade
1000mm F12.5 TELEPHOTO MIRROR LENS
$199

1000mm/11.0	$279
1000mm/10.0	$379
2000mm/10.0	
8″ Spotting Scope	$599
Spotting Scope Kit	$59

Meade
COMET SEEKER
ZOOM 12-50x POWER TELESCOPE
$129
Adapts To All 35mm Cameras To Become 750mm-3200mm Telephoto Lens

Bushnell
SPACEMASTER TELESCOPE
$119
ALL EYEPIECES IN STOCK
15 — 45x ZOOM — 60x — 40x
25x — 20x — 22x — WIDE ANGLE

CELESTRON
C-90 SPOTTING SCOPE
$259
C-90 ASTRO SCOPE IN STOCK GREATLY REDUCED
ALL ACCESSORIES IN STOCK

BAUSCH & LOMB
CRITERION 4000 TELESCOPE
$399

CRITERION 4000 TELEPHOTO LENS	$239
CRITERION 8000	IN STOCK

WE CARRY A FULL LINE OF 35mm SLR CAMERAS • LENSES AND ACCESSORIES

Meade
8″ MODEL 2080 SCHMIDT CASSEGRAIN TELESCOPE
$795
Meade 2080 Lx/2080 Lx2 8″ Schmidt Cassegrain Telescopes in Stock

CELESTRON
SUPER C-8 PLUS SCHMIDT CASSEGRAIN TELESCOPE IN STOCK GREATLY DISCOUNTED
Also Available: Super C-8 Plus Starbrite • Super Polaris C-8 • Super Polaris C-80 Starbrite • C-11 & C-14 Telescopes

CELESTRON
C-80 REFRACTING TELESCOPE
$429

Firstscope 80	$399
Superpolaris SP-C80	$549
Sky Sensor	$349
C-80F Fluorite	$1,099
C-102 Refracting	$599
Superpolaris SP-C102	$799

CELESTRON
C-6 NEWTONIAN REFLECTOR
$529

COMET CATCHER	$259
COMET CATCHER EQUATORIAL MOUNT	$329
COMET WATCHER	$99
COMET CATCHER JR.	$199

ALL ACCESSORIES IN STOCK

BAUSCH & LOMB
DISCOVERER
ZOOM 15 - 60x POWER TELESCOPE
$187
ADAPTS TO ALL 35mm CAMERAS TO BECOME 1000-4000mm TELE./ZOOM

Meade
2.4″ ALTAZIMUTH REFRACTING TELESCOPE
$129

CELESTRON-COMETRON 40	$59
CELESTRON-COMETRON 60	$99
DELUXE COMETRON 60	$179

ORDER NOW!

FOR PHONE ORDERS ONLY
CALL TOLL FREE
1 • 800 • 223 • 0322
NEW YORK RESIDENTS CALL
(212) 757-6688 (212) 582-4294
WE ACCEPT ALL MAJOR CREDIT CARDS
ON ALL PHONE ORDERS CALL
MONDAY — SATURDAY 9:30 AM - 9:00 PM
SUNDAY 11 AM - 8 PM

All Merchandise Brand New. Factory Fresh. Minimum Shipping & Handling Charge $7.95. Quantities May Be Limited on Some Items — Refunds Within 7 Days With Original Packaging And Unfilled Guarantee Card. Please Call Before Sending Any Money Orders. Some Acc. May Be Add. From Original Packaging. Not Responsible For Typographical Errors. Some Items Add. For Warranty in U.S.A. For Customer Service Please Call 12:30 pm - 6:30 pm.

STAR TRACKER

THE MOST COMPLETE TELESCOPE
STORE IN THE KNOWN UNIVERSE

COME IN AND COMPARE

Write for the world's finest telescope
Catalog and Reference Manual
$2 U.S.A. $4 Foreign

3093 WALNUT
BOULDER, COLORADO 80302
(303) 442-6805

NEW ENGLAND
ASTRO-OPTICS

• QUESTAR • MEADE • TELEVUE •
BUSHNELL/BAUSCH & LOMB • JSO
COULTER   LUMICON

master charge   VISA

CATALOG PACKAGE $1.00
Box 834, Simsbury, CT 06070
203-658-0701

TCU 685   OUR 2nd YEAR   70055,205

FREE **Complete Catalog Package. Just Write or Call.**
Foreign $5.

We Sell And Ship To The World

Visit the largest and most complete telescope showrooms in the United States

NOW *Three Locations To Serve You*

Scope City

Main office, mail order and showroom

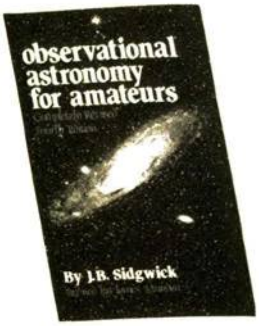
679 Easy Street
Simi Valley, California 93065
(805) 522-6646

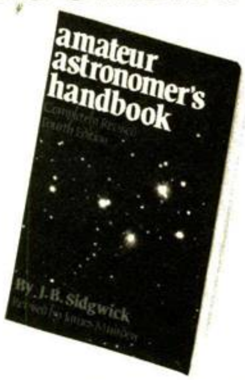
3033 S. Bristol
Costa Mesa, California
(714) 957-6900

3132 Pacific Coast Hwy.
Torrance, California
(213) 326-3251

Open Mon. - Sat. 9-6

Observer's Bookshelf





Observational Astronomy for Amateurs, 4th ed.: Sidgwick. A comprehensive collection of facts on observing techniques covering the Sun, Moon and all the planets, as well as aurorae, meteors, zodiacal light and double stars. 348 pages, paperback, **$8.50.**

Amateur Astronomer's Handbook, 4th ed.: Sidgwick. Tips on mountings and drives, eyepieces, mirror and lens testing — as well as data on human vision, the Earth's atmosphere, and time-reckoning systems. 568 pages, paperback, **$10.50.**

Both books have been completely revised and updated by James Muirden and are designed as companion guides. Order them individually, or save and purchase a set of both for only $17.95.

To order, use the AstroMedia order form bound into this issue, or send to AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

ASTRO MART

FOR SALE — Edmund reflector telescope, 6" f/6 with fork mount and drive motor, RKE Barlow lens, 12mm eyepiece, and 12V inverter. All for $475 firm. Contact F. Bishop, 32 Abrams Hill, Duxbury, MA 02332. Phone (617) 934-5879.

FOR SALE — Aquarius Home Computer, includes keyboard, 8K memory expander, two control paddles, and instruction book. $50. Contact Mark Coco, 1120 Ysabel St., Redondo Beach, CA 90277.

FOR SALE — Celestron Comet Catcher, new design, used twice, $240; C-80 refractor, equatorial, like new, $400; 4¼" Edmund reflector, equatorial, excellent condition, $190; 2" o.d., 40mm Vernonscope giant Erfle, $100; 1¼" o.d. 16.3mm Criterion Erfle, $38. Shipping included on all. Contact Roger DeKing, Floral Park #190, 1701 State Fair Blvd., Syracuse, NY 13209. Phone (315) 638-8846.

WANTED — Contact with clubs or observers in northwest Washington state/southwest British Columbia. I'm new to the area and would like to learn of observing sites. Contact Tom Masterson, 3700 Taylor Ave., Bellingham, WA 98226. Phone (206) 647-2881.

WANTED — No. 3E 1475 A. Jaegers objective. Contact E.E. Huffman, Route 9, Box 1079, Hickory, NC 28601. Phone (704) 256-2580.

WANTED — Anything showing Halley's or earlier comets. Must be pre-1911 (i.e., cartoons, postcards, jewelry, etc.). Contact Stuart Schneider, Box 64, Teaneck, NJ 07666.

METEORITES

AVAILABLE TO
ASTRONOMERS, SCHOOLS
INSTITUTIONS AND PRIVATE
COLLECTORS. STONES & IRON
SPECIMENS. **LIMITED SUPPLY,**
ROBERT A. HAAG — METEORITES
Box 27527, Tucson, AZ 85726
— PLEASE SEND $1.00 FOR FULL COLOR CATALOG —
Refundable on first order

TEXAS NAUTICAL REPAIR CO.

Authorized Meade Dealer

COME AND SEE

THE FINE TELESCOPES AND ACCESSORIES BY MEADE IN OUR SHOWROOM. WE HAVE IT ALL AND OTHER POPULAR MAKES.

3209 MILAM
HOUSTON, TEXAS 77006
(713) 529-3551

Master Card   American Express   Visa

NEW ZEALAND

HALLEY'S WATCH

See New Zealand as guests of Astronomical Societies of NZ. Including all air and land arrangements from only $1365. 7-14 day itineraries for Halley's Comet Watch 1985/6. Call Rainbow Adventure Holidays for complete brochure.

US 800-722-2288
CA 800-227-5317

ASTRO MART

WANTED — Metrogon lenses, 6" and 12" f/6.3 in very good condition. Contact P. Koczet, Laerheidestr. 28, D-4630 Bochum, West Germany.

WANTED — Astronomy programs for the Vic-20, cassettes or listings, will buy or trade. Also looking for people in Wayne/Monroe County, New York, interested in observing. I have 3" and 10" reflectors. Contact William Cantwell, 870 Ridge Rd., Ontario, NY 14519.

WANTED — Photos, posters, patches, books, information sheets, etc. having to do with astronautics and/or aviation, especially early space projects (Mercury, etc.) and high performance U.S. jets. Contact Alan Sanchez, 408 Richburn Ave., La Puente, CA 91744.

WANTED — Collectibles from Mercury, Gemini, and Apollo programs (toys, records, jewelry, models, posters, photos, etc.). Will buy one item or entire collection. Send your list of items and prices to Jeff Walker, 1370 Kelly Ln., Dubuque, IA 52001.

WANTED — Timex/Sinclair 1000 astronomy programs (Ephemerides, orbit calculations, time calculations, etc.), also information about where I can get a cheap T/S 2040 printer (or other with corresponding cable) with paper. Contact J. Farr, 301 Tenth Ave., Butler, PA 16001.

WANTED — Complete set of leaflets published by the Astronomical Society of the Pacific starting with Leaflet #1 published in May 1925 to Leaflet #510 published in December 1971. Contact J.T. Unruh, P.O. Box 13375, Sacramento, CA 95813. Phone (916) 451-7744.

When writing to advertisers please mention you saw their advertisement in ASTRONOMY

UNBEATABLE

PRICES ON CELESTRON AND OMNICON ASTRONOMICAL TELESCOPES

SOME EXAMPLES:

CELESTRON C-8M Complete with Equatorial Mount, Slow Motion Controls, Tripod, Worm Gear Motor Drive and Slow Motion Polar Axis.	'995
CELESTRON C-11 Complete witih Tripod, Wedge and Slow Motion Polar Axis Controls.	'2495
1. CELESTRON COMET CATCHER	'445
2. OMNICON 515ST 6" f/5 NEWTONIAN	'395
3. OMNICON 158ST 80MM f/15 REFRACTOR	'325

All three complete with Equatorial Mount, Slow Motion Controls, Worm Gear Motor Drive, All Metal Extendable Tripod and more!

$2.00 — 24 PAGE
ASTRONOMICAL CATALOG

Sky Instruments • Box F195-105 • Blaine, WA 98230
Canadians: MPO Box 3164 • Vancouver, B.C. • V6B 3Y6

(604) 270-2813

CANADA

NEW & USED SCOPES, BINOCULARS, BOOKS, ASTRO FILMS & PROCESSING

CANADIAN DEALER for:
BAUSCH & LOMB, BUSHNELL, CELESTRON, DAYSTAR, JSO, LUMICON, MEADE, SWIFT, TASCO, TELEVUE, WETZLAR, ZEISS, AND MORE

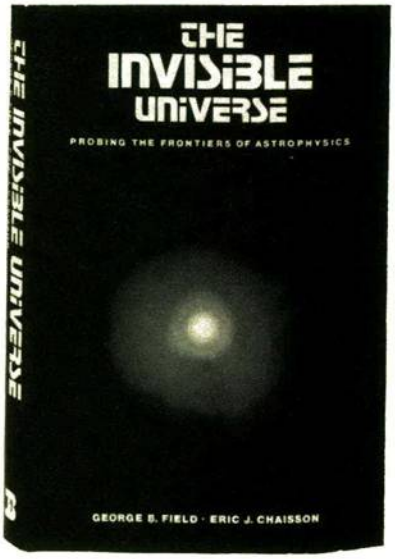
"Compare our selection and price"

QUASAR OPTICS

7719 FLEETWOOD DR. S.E.
CALGARY, ALBERTA T2H OX2
(403) - 255 - 7633

PROBING THE FRONTIERS OF ASTROPHYSICS

THE INVISIBLE UNIVERSE


THE INVISIBLE UNIVERSE
THE INVISIBLE UNIVERSE
PROBING THE FRONTIERS OF ASTROPHYSICS
GEORGE B. FIELD · ERIC J. CHAISSON

George Field & Eric Chaisson
December 1984 / Hardcover / $19.95
Book-of-the-Month Club / Science Selection

IMPORTANT.
—NASA decisions, strategies, and goals for the Eighties.

ACCESSIBLE.
The Invisible Universe *is a delight! Written for the non-specialist, it is a beautiful but authoritative account . . . enlivened by wonderful color pictures and fascinating personal anecdotes."*
—John N. Bahcall, Professor of Astrophysics
Institute for Advanced Study, Princeton, NJ

"UNUSUAL AND WELCOME. . ."
—Alan Lightman, Astrophysics
Harvard Smithsonian Center for Astrophysics

Available in bookstores now.
Or use coupon to order

Please send me ______ copies of **THE INVISIBLE UNIVERSE.** 0-8176-3235-5 / $19.95
☐ payment enclosed $ ______
☐ VISA ☐ Mastercard
Card No. __________ Exp. Date ______
Signature ______________________
Name ______________________
Addresss ______________________
City ______________________
State / Zip ______________________
Please include $1 shipping and handling.
Mass. residents, please add 5% sales tax.

Birkhauser Boston,
Publisher for the Mind.
380 Green Street
Cambridge, MA 02139
(617)576-6638

STS-51A Emblem Features Satellite Retrievals

ALLEN FISHER GARDNER
HAUCK WALKER

The 51A mission of the Space Shuttle *Discovery* is symbolized on this multi-colored embroidered emblem with NASA's official design. The mission highlight is the retrieval of 2 communications satellites launched on previous missions, which never reached their proper orbits.

Great for your jacket or cap!

STS-51A **5" x 4"** **$4.95**

To order, use the AstroMedia order form bound into this magazine or send to: AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

Celestron Demonstration/Sale in Columbus, OH

Sat. April 13, 1985 (9 a.m. to 10 p.m.)
Holiday Inn - Columbus North, 1212 E. Dublin - Granville Rd. (I-71 & 161), Columbus, OH

- Telescope viewing - weather permitting
- How to use your telescope
- Bring your SLR & video cameras
- Comet Halley info.

SPONSORED BY:

Optics Ohio
P.O. Box 1439
Lancaster, Ohio 43130

Cosmic Connections, Inc.
1460 N. Farnsworth Ave.
Aurora, Illinois 60505

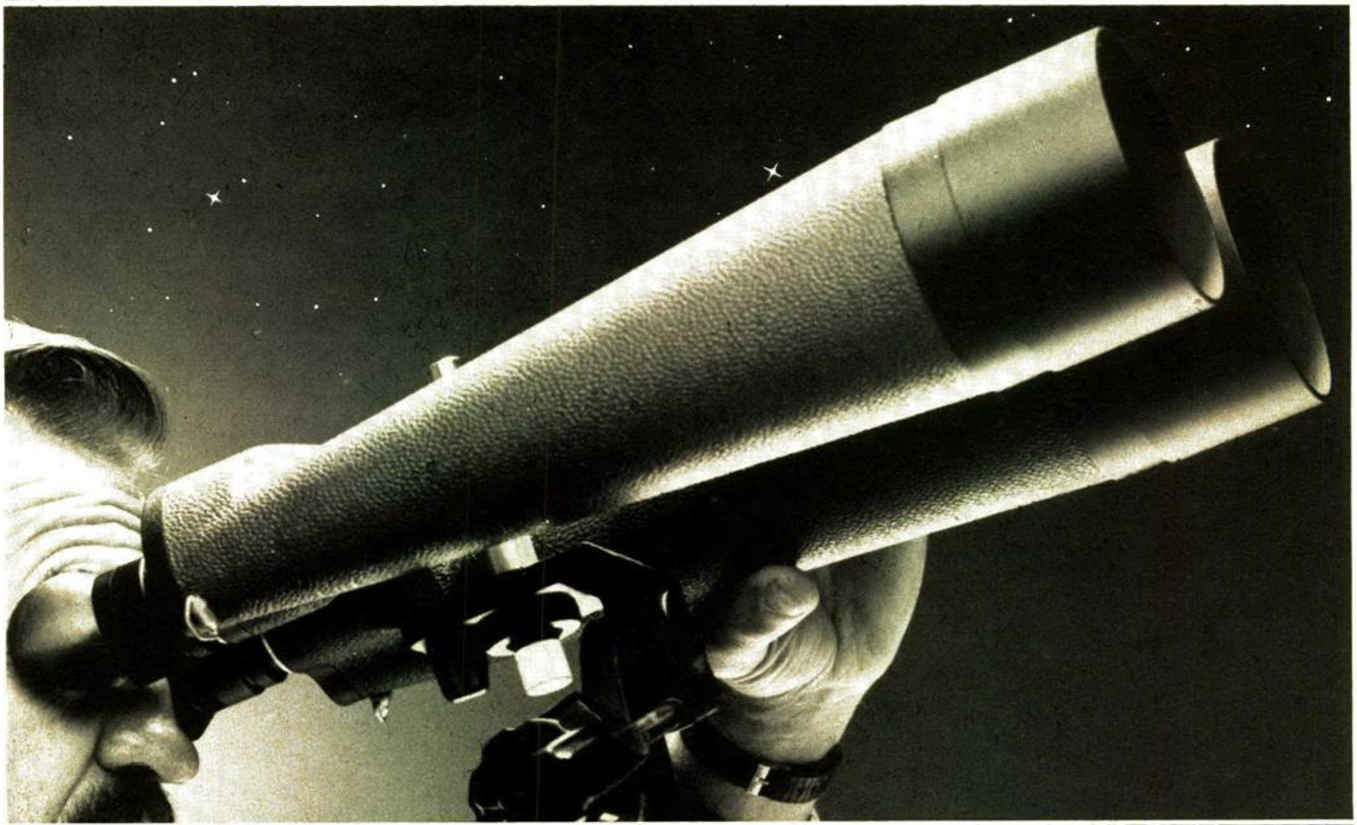
Buy TeleVue from us!

Plossls	
55mm	$160
40, 32mm	(ea) 80
26, 21, 17, 13, 10.4, 7.4, 2.5x	(ea) 65
Naglers	
13mm	$220
9mm	195
4.8mm	125
Wide Fields	
40mm	$250
32mm	195
24mm	125
19mm	110

312-851-5353
Telescopes & Binoculars Repaired

Master Card - VISA - American Express accepted * Catalog $2

CELESTRON— THE GIANT NAME IN BINOCULARS.



Giant binocular telescopes are extremely effective — and unbelievably exciting — astronomical instruments. These giant binoculars make a perfect addition to any astronomer's gear.

Deep sky objects seem to explode into wide angle view. You'll see huge, detailed expanses of sky, including globular star clusters, nebulae and galaxies. Even the dust lanes of Andromeda are visible, under a dark sky. And you'll see it all with a richness and depth you've never before experienced.

Every Celestron Giant Series binocular features a huge 80mm objective lens, for immense light-gathering. They are of porro prism design with laser-tested optics and are fully anti-reflection coated with magnesium fluoride (MgF_2). (The Deluxe 20x80's are multicoated for the sharpest image.) Each comes with a limited lifetime warranty.

Four models are available: 11x80, 20x80, 30x80 and the new 20x80 Deluxe with Sharp Star coated optics. Just ask for Celestron — world's leading supplier of giant binoculars.

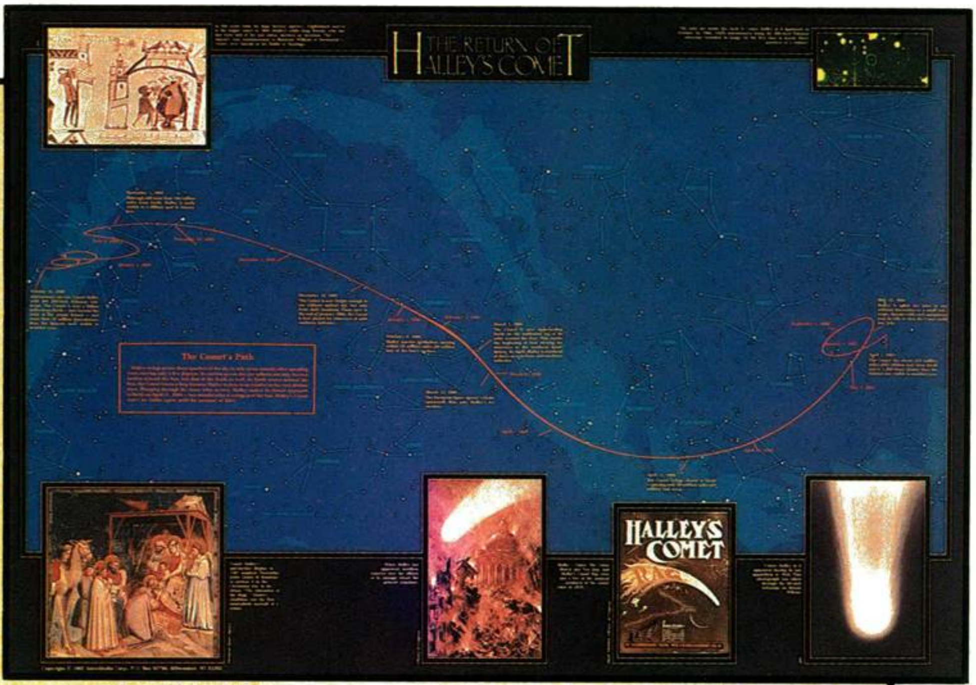
For Dealer Locations, Catalogs, Information, Technical Data Sheets

CALL FREE 1-800-421-1526

(Mon-Fri; 8-4:00 Pacific Time; Continental USA only)
CELESTRON INTERNATIONAL,
P.O. Box 3578B3C 2835 Columbia St.,
Torrance, CA 90503 (213) 328-9560

CELESTRON®
PRECISION OPTICS

Display Comet Halley On Your Wall


THE RETURN OF HALLEY'S COMET
The Comet's Path
HALLEY'S COMET

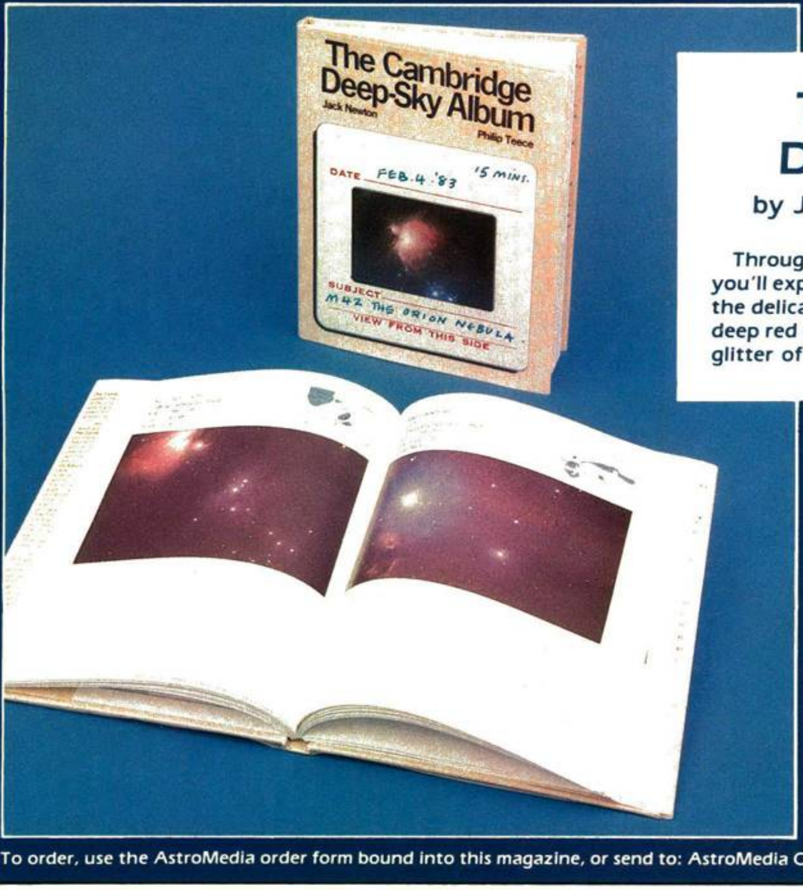
- Accurate
- Scientific
- Historic
- Useful
- Handsome
- Unique

When Halley's Comet returns this year, keep up-to-date on where it is with **THE RETURN OF HALLEY'S COMET** from AstroMedia. Measures 21'' x 30'', suitable for framing. Order now!

THE RETURN OF HALLEY'S COMET

$4.95

To order, use the AstroMedia order form bound into this magazine, or send to AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202.


The Cambridge Deep-Sky Album
Jack Newton
Philip Teece
DATE FEB. 4 '83
15 MINS.
SUBJECT M42 THE ORION NEBULA
VIEW FROM THIS SIDE

The Cambridge Deep-Sky Album

by Jack Newton and Philip Teece

Through the magic of modern astrophotography, you'll experience the thrill of deep-sky observing — the delicate blue in the arms of spiral galaxies, the deep red of glowing hydrogen nebulae, the silvery glitter of star clusters — and more.

- 136 beautiful images — all in color
- includes galaxies, nebulae and star clusters
- authoritative text and data with each plate
- objects identified by M- and NGC-numbers
- each image enlarged to uniform scale
- hardcover, 126 pages

The Cambridge Deep-Sky Album

$19.95

Foreign orders add $1.50

To order, use the AstroMedia order form bound into this magazine, or send to: AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

Equipment
Atlas

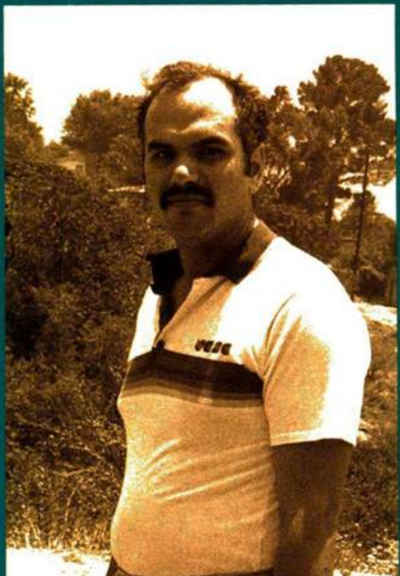
Build a Simple Folded-Refractor Telescope

by
Steve Edberg

Having begun my astronomy career in solar physics, I've grown used to checking daily for sunspots. When I switched to cometary astronomy, my desire to keep tabs on the Sun was still strong, so I designed and built a small refractor. I can carry it in and out of my office easily, placing it on a platform for observations.

The instrument is a 2-inch f/25 folded refractor. The objective was a spare I had in my optics box, which originally came from A. Jaegers Optical. I bought two 1.83″ cosmetic-second diagonals from Coulter Optical to fold the light path into a "Z" shape. The diagonals are oversize, so the chips at the edges (that's why they were seconds) don't affect the optical performance. A glass solar filter completes the main optics.

The telescope tube is actually a box of ¼″ A-D grade plywood. Half-inch square pine reinforces the box's internal edges (see photos) and holds the screws of the removable side panel. The corners holding the diagonals also have a reinforcing piece. I painted the box black inside (white outside, of course), then glued and nailed it together.



A short length of 2″ ABS pipe holds the objective (I had to ream out the pipe slightly) and also baffles scattered light. I squared the pipe to the box with two corner brackets, then modified some small metal cable clamps and added cork to secure the mirrors in their corners. A 1¼″ focuser finishes the optical assembly.

Suppliers' Addresses

.Coulter Optical Co.
P.O. Box K
Idyllwild, CA 92349

A. Jaegers Optical Co.
691S Merrick Rd.
Lynbrook, NY 11563

Jerryco
5700 Northwest Highway
Chicago, IL 60646

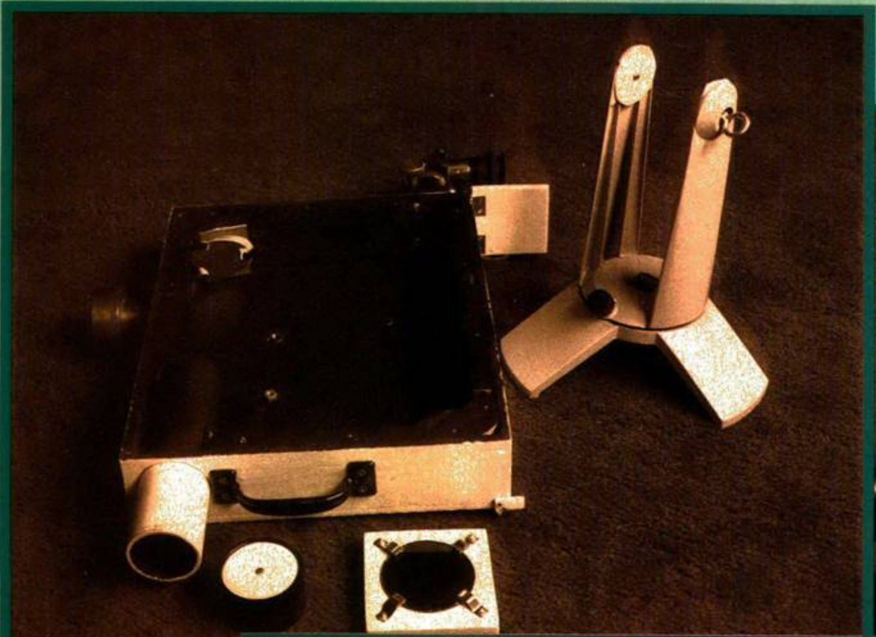
A standard plastic pipe end cap fitting makes an excellent lens cover; with a small hole drilled in the center, it's also an aid for aligning the optics. (I plug the hole with a bolt to keep dust out when it's a lens cap.) Using a standard collimating eyepiece and the drilled cap, I twiddled the diagonals until the optical and mechanical axes were aligned.

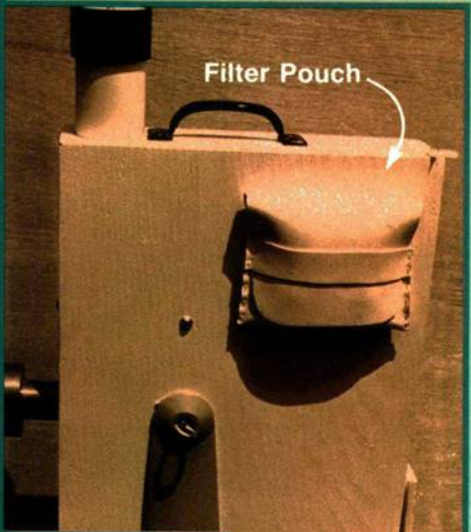
The mounting is a surplus Edmund Scientific alt-azimuth fork purchased from Jerryco, but a homemade wooden mount wouldn't be hard to build using basic Dobsonian technology. I designed the tube to fit between the fork tines and swing 90° in altitude. Naugahyde pads on the fork tines prevent scratches on the box when I clamp the ¼-20 axle bolt into its tee-nut. Since the pivot point isn't at the center of gravity, I also use a counterweight.

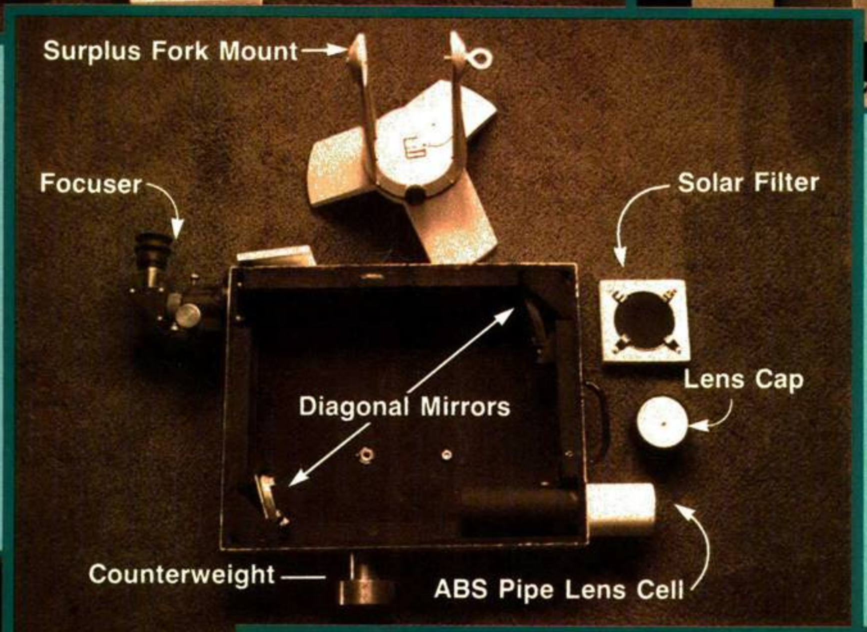
I use a peep sight for aiming the telescope, except when lining up on the Sun. With the Sun, the front peep sight projects its shadow on a flip-up target at the back end of the tube; when aimed right, the shadow falls on an index. The flip-up piece also keeps direct sunlight off the eyepiece. I mounted the solar filter in a plywood cell; it slips snugly over the ABS pipe. The filter case rides on the side of the tube. For transport, the diagonal and eyepiece clamp down in the focuser. A handle on the box makes the whole package easy to carry with one hand.

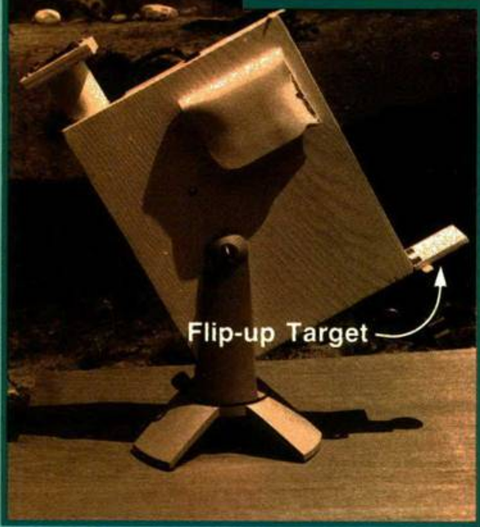
I've been using this simple telescope for daily visual observations, and have even used it to photograph the Sun through a full solar rotation. A very small investment in time and money has produced delightfully large results.

Steve Edberg is a planetary scientist at the Jet Propulsion Laboratory in Pasadena, California. He is the coordinator of amateur observations for the International Halley Watch.

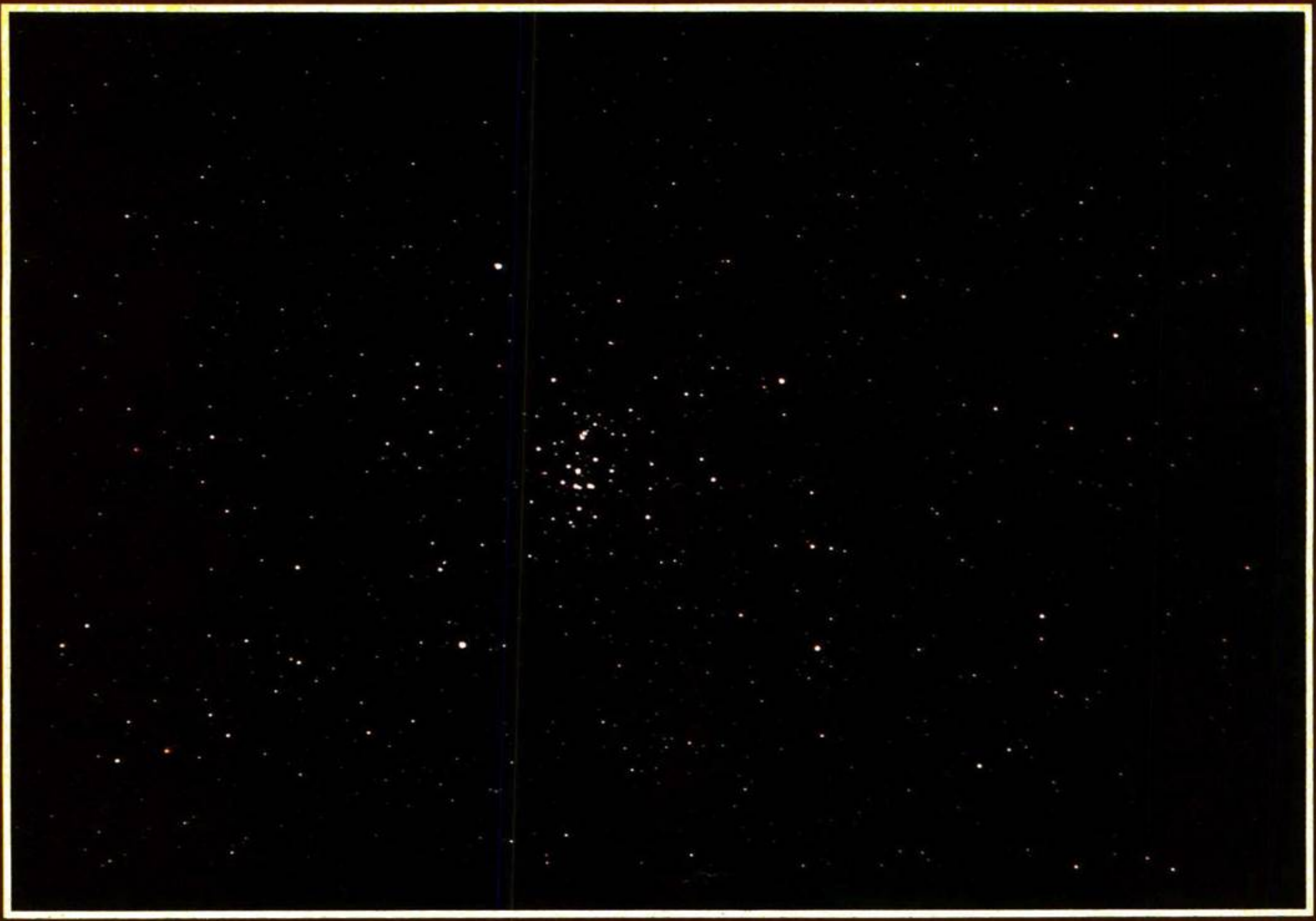


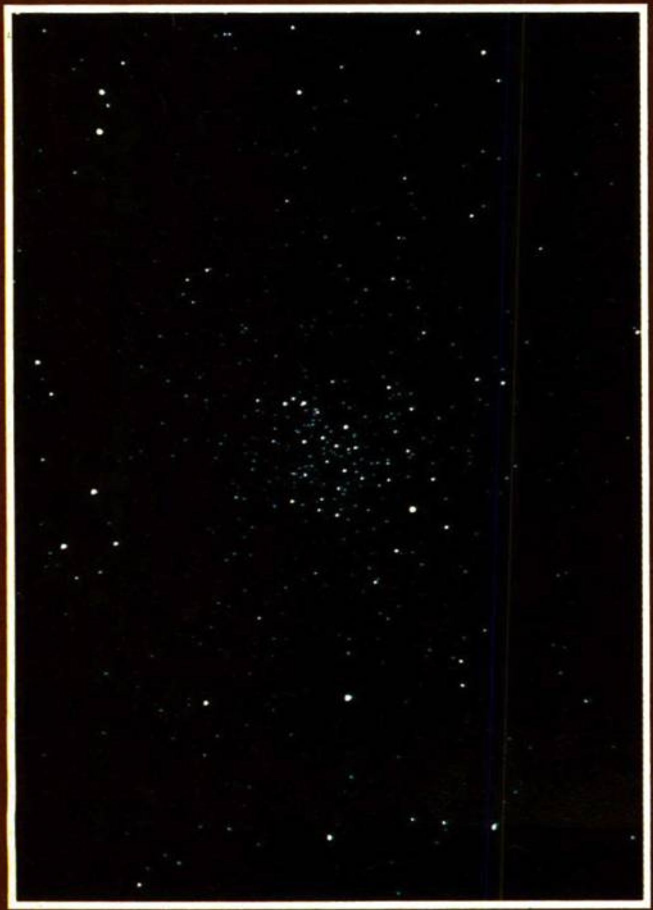

Filter Pouch


Surplus Fork Mount
Focuser
Solar Filter
Lens Cap
Diagonal Mirrors
Counterweight
ABS Pipe Lens Cell


Flip-up Target

Naugahyde Pad

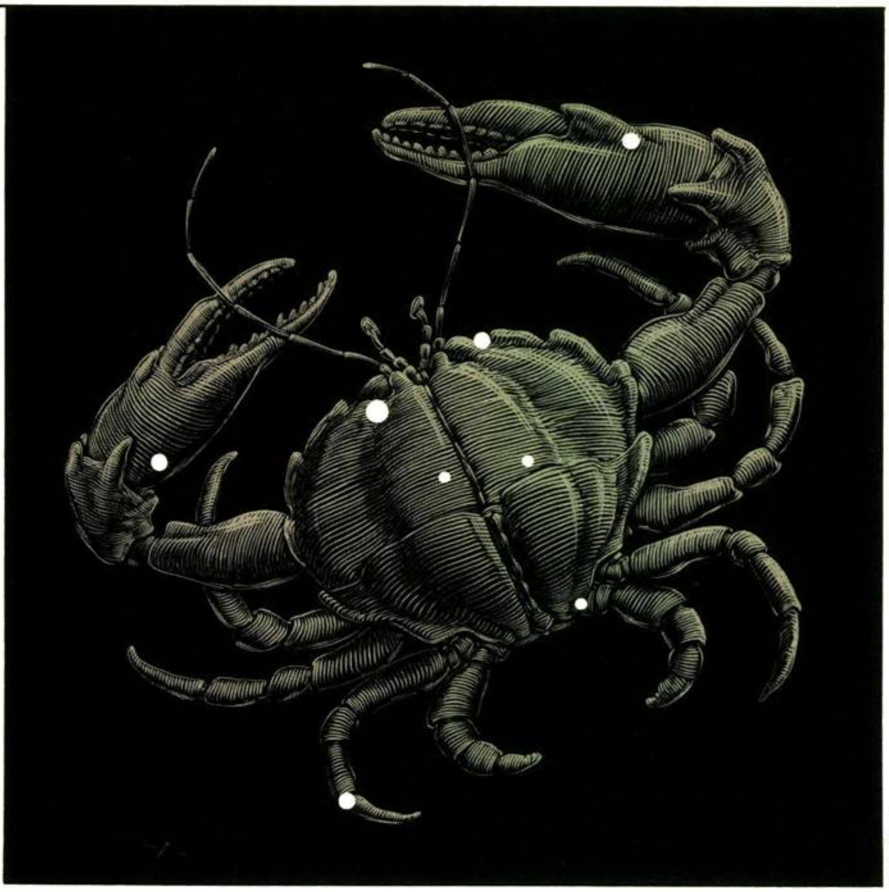




Above: The Beehive star cluster, M-44, is a bright open star cluster visible to the naked eye. Low-power telescopes show a rich collection of several dozen stars. Photo by Alan Dyer. Left: M-67, another of Cancer's open clusters, is one of the oldest such objects known. Photo by Lee C. Coombs. Below: NGC-2623, a faint spiral galaxy, has peculiar warped extensions. Photo by Jack Newton.

Cancer

Cnc
Cancri



Keith Ward

Cancer the Crab, nestled between the much brighter constellations Gemini and Leo, consists of half a dozen dim naked-eye stars. To the naked-eye viewer under fair conditions, Cancer is one of the least commanding of spring's star groups. Under dark skies, however, one of the sky's best open clusters shows as a fuzzy patch of light. And with the aid of a telescope, Cancer reveals a second unusual open cluster and numerous small galaxies.

Take a look toward Cancer on a dark, transparent night: you'll undoubtedly see **Messier 44** (NGC-2632), the Beehive Cluster, which appears as a huge patch of unresolved stars measuring nearly three Moon diameters across. It is one of the brightest, largest, and nearest open clusters. Binoculars or finderscopes show the Beehive as a grand grouping of several dozen stars, the brightest of which — Epsilon (ε) Cancri — shines at sixth magnitude. M-44 contains 80 members brighter than 10th magnitude, enabling a low-power telescope to show a dazzling field loaded with bright stars; many are blue-white, white, yellow, or subtle orange in color. M-44's total membership is approximately 200 stars — the faintest glow at 14th magnitude — half of which are intrinsically brighter than the Sun. (If placed at M-44's distance, the Sun would appear as a magnitude 10.9 speck of light.)

Throughout history, M-44 acquired a variety of names from different cultures. Ancient Greeks, such as Hipparchus (130 B.C.) and Aratus (260 B.C.), called it the "little mist" or "little cloud" and used M-44 as a weather indicator. If M-44 was invisible after darkness fell, they believed a storm would soon arrive. The Chinese gave it the more macabre name Tseih She Ke, meaning "the exhalation of piled-up corpses." The Latins named it Praesepe, a common name for M-44 today. These observers knew nothing *about* the fuzzy patch in the sky; it wasn't until 1610, when Galileo trained a telescope on M-44, that he discovered its stellar nature.

Cancer's second open cluster is **Messier 67** (NGC-2682), a bright group of stars much smaller than M-44. M-67 appears as a rich cluster, since its 200 stars (between magnitudes 10 and 16) are packed into an area just 15′ across. M-67 physically resembles the Beehive Cluster, but at 800 parsecs' distance lies five times farther away. It measures three parsecs across — compared to M-44's diameter of 13 parsecs — and, unlike most open clusters, it lies far above the plane of the Milky Way. M-67 shows a distribution of stars similar to a globular cluster rather than a galactic group of stars. M-67's brightest stars are almost 10 billion years old — much older than most open clusters.

In a small telescope, M-67 looks like a shimmering spangle of stars floating in an unresolved haze. A 6-inch scope at 100x shows several dozen individual stars, most of them colored bluish-white, white, yellow, or subtle orange. A 12-incher at high power transforms M-67 into a grand sight: a hundred stars neatly arranged in a circular clump.

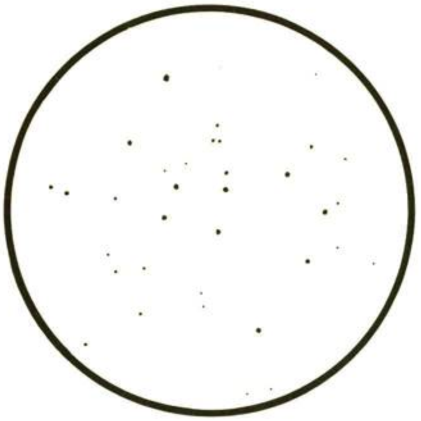
The finest triple star in Cancer is **Zeta (ζ) Cancri** (Σ1196), a magnitude 5.6 and 5.9 pair separated by a mere 0.9″ in p.a. 337° (1968). These two stars orbit each other once every 59.6 years, separating from 0.6″ to 1.2″, then back again. The actual distance between the stars is 19 astronomical units — approximately the distance separating the Sun and Uranus. The third star is Zeta C, a magnitude 6.0 object, which lies at a distance of 5.8″ in p.a. 83° (1962). The separation between the A-B pair and star C is approximately 175 astronomical units. Intensive study of Zeta Cancri revealed that star C probably has an invisible companion, likely a white dwarf. The system lies 20 parsecs away, with its three visible stars appearing yellowish. A 4-inch scope at high power handily separates all three components.

R Cancri is a worthwhile long-period variable, or Mira-type star. Displaying a strong ruddy color, R Cnc is easy to follow in binoculars or a small telescope as it undergoes a 362-day period of variability. At maximum, R Cnc is visible to the naked eye as a magnitude 6.1 red star. At minimum, the star fades to magnitude 11.5 and becomes slightly redder; see if you can detect any change in color as the star fades below naked-eye visibility. **X Cancri** is a semi-regular variable star with a much smaller amplitude, varying between magnitudes 6.2 and 7.5 over a period of 170 days. Binoculars, with their wide fields and increased light-gathering power, are best suited for observing this

For information on naked-eye sky viewing, including planets, constellations, and mythology, see **Eye on the Sky**.

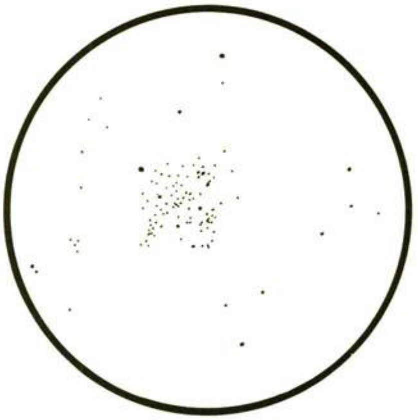
M-44

8-inch f/5 SCT
35x



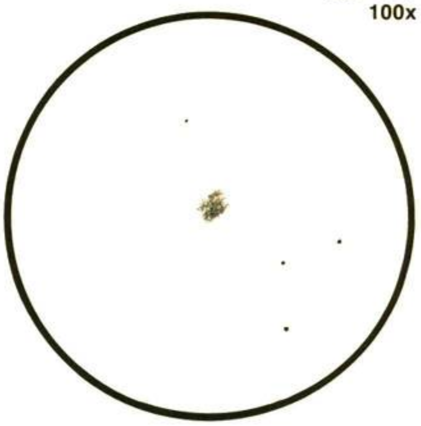
M-67

8-inch f/10 SCT
100x



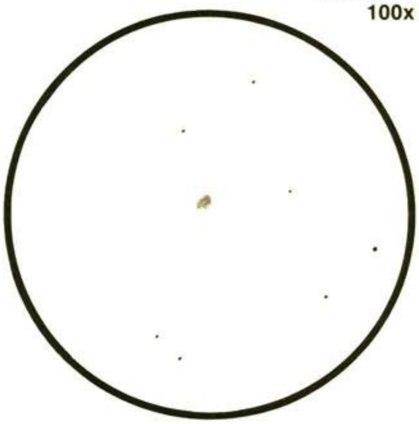
NGC-2623

8-inch
f/10 SCT
100x



NGC-2775

8-inch
f/10 SCT
100x



Sketches by David J. Eicher

star. Another variable in Cancer is **SY Cancri**, an irregular star of the Z Camelopardali type. Stars like SY Cancri are sometimes called "dwarf novae," as they occasionally display minor eruptions for two to three weeks, then rise to maximum in about two days. Sometimes the stars stay constant for weeks or months. At any given time, SY Cnc may be as bright as magnitude 9.5 or considerably fainter than 12.

Cancer houses a slew of faint galaxies well worth finding in backyard telescopes. The most noteworthy is **NGC-2623**, a peculiar spiral galaxy showing extended filaments of material on long-exposure photographs. This suggests that NGC-2623 may be two colliding galaxies, but these streamers are impossibly faint to see in a telescope. At 14th magnitude, this galaxy is difficult to find in anything less than an 8-inch scope, which shows an elongated streak of light that is slightly brighter in the middle.

Easier to find is **NGC-2545**, a nearly face-on type Sb spiral shining at magnitude 13 and measuring 1.1′ x 0.9′. NGC-2545 lies just 4′ east of an eighth-magnitude star, which makes it simple to locate but also hinders viewing because of the glare — try moving the star just out of a medium-power field. A 6-inch telescope shows a uniform circular haze with a condensed core, and a 10-inch scope shows it brighter and better defined. Long-exposure photos reveal a faint outer ring around this galaxy, but it — like NGC-2623's streamers — is much too faint for direct viewing.

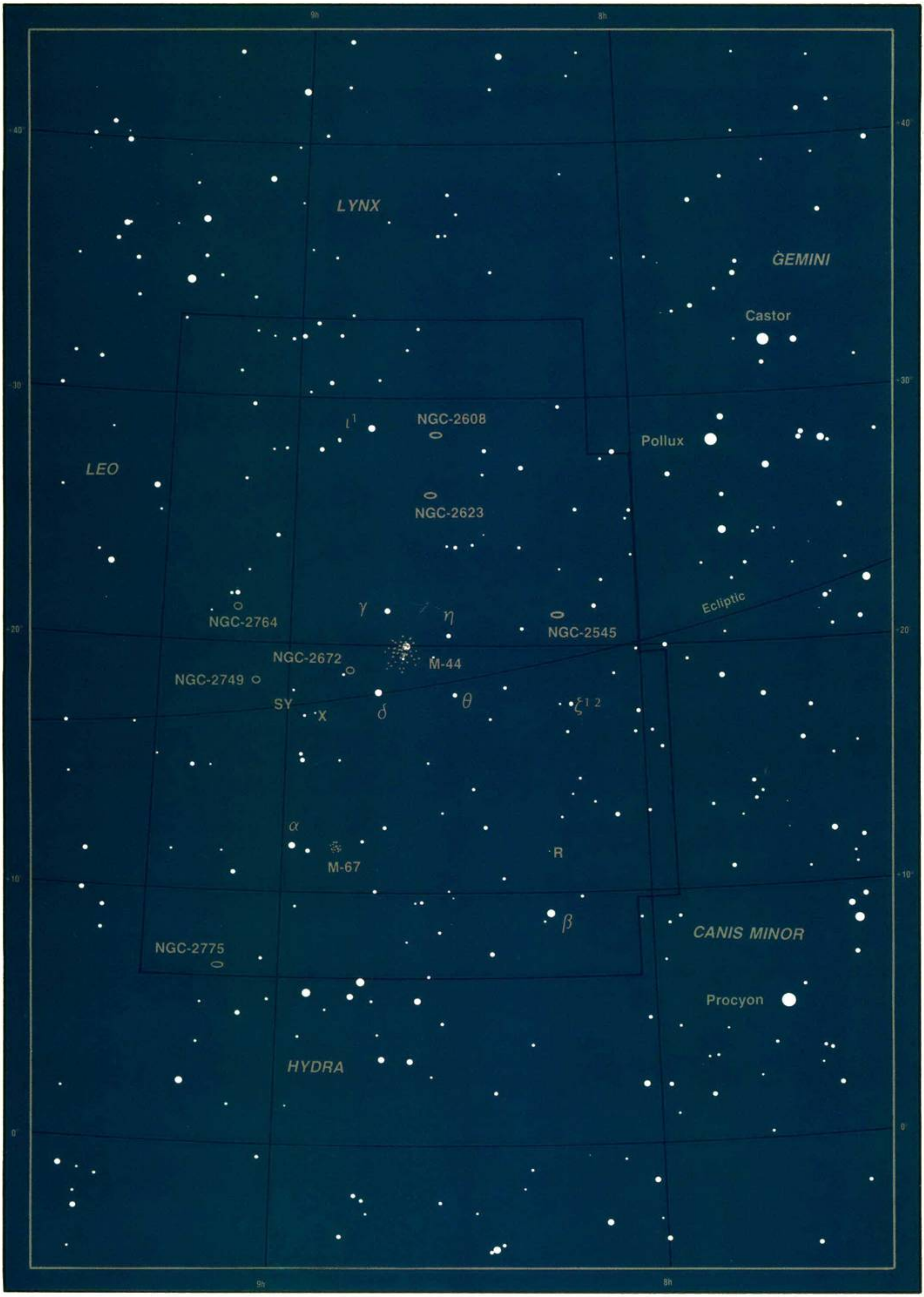
Cancer's brightest galaxy is **NGC-2775**, which appears as an 11th magnitude oval smudge of nebulosity in a 6-inch scope. A 10-incher shows this Sa-type spiral as a smooth oval envelope surrounding a tiny, bright nucleus. This object measures 2.2′ x 1.5′ and has a high surface brightness, so it can withstand plenty of magnification. Another fine spiral, **NGC-2608** measures 1.7′ x 0.8′ and shines at magnitude 12.8. It is considerably fainter than NGC-2775 and appears as a grainy, mottled haze surrounding a moderately condensed center.

Three tiny galaxies in Cancer could, on unsteady nights, be mistaken for stars. **NGC-2672**, a magnitude 12.6 elliptical, measures only 24″ x 18″ — about the size of a typical faint planetary nebula. **NGC-2749** is slightly larger, 48″ x 36″, but fainter at magnitude 13.2. A third elliptical — **NGC-2764** — measures 54″ x 30″ and shines at magnitude 13.3. These three fuzzy balls of light — each representing millions of stars — may be tricky to observe. Wait for a dark, steady night and use high power; you'll see them as nebulous "out-of-focus stars."

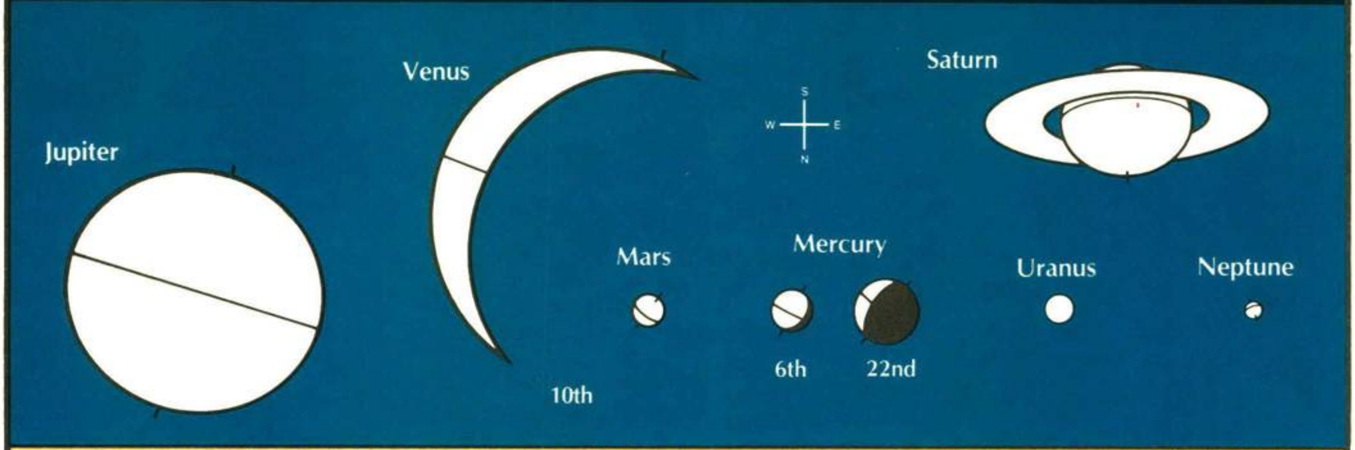
Object	M#	Type	R.A. (2000)	Dec.	Mag.	Size/Sep./Per.	H
Zeta^{1,2} ($\zeta^{1,2}$)		★^{2}	8h 12.1m	+17°39′	5.5,6.0	0.9″	
NGC-2545		§	8h 14.2m	+21°21′	13.0	1.1′x0.9′	Sb
R		LPV	8h 16.5m	+11°44′	6.1↔11.5	362d	
NGC-2608		§	8h 35.2m	+28°28′	12.8	1.7′x0.8′	Sc
NGC-2623		§	8h 38.4m	+25°46′	14.0	2.0′x0.4′	Spec
NGC-2632	M-44	⊙	8h 40.4m	+19°41′	4.5	80′	
NGC-2672		0	8h 49.4m	+19°05′	12.6	0.4′x0.3′	E1
NGC-2682	M-67	⊙	8h 51.0m	+11°49′	7.0	15′	
X		SRV	8h 55.4m	+17°14′	6.2↔7.5	170d	
SY		IV	9h 01.0m	+17°53′	9.5↔12.0	Irr	
NGC-2749		0	9h 05.3m	+18°19′	13.2	0.8′x0.6′	E2
NGC-2764		0	9h 08.3m	+21°27′	13.3	0.9′x0.5′	E3
NGC-2775		§	9h 10.4m	+ 7°03′	11.5	2.2′x1.5′	Sa

H = Hubble classification type for galaxies

★^{2}	*Double Star*
LPV	*Long Period Variable*
SRV	*Semi-Regular Variable*
IV	*Irregular Variable*
⊙	*Open Star Cluster*
§	*Spiral Galaxy*
0	*Elliptical Galaxy*

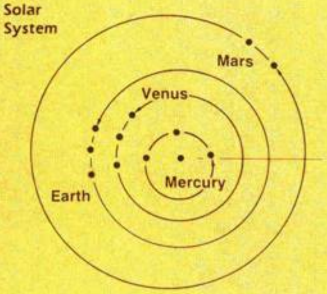

9h
8h
40°
30°
20°
10°
0°
LYNX
GEMINI
Castor
LEO
ι¹
NGC-2608
Pollux
NGC-2623
γ
η
NGC-2764
NGC-2545
Ecliptic
NGC-2672
M-44
NGC-2749
SY
X
δ
θ
ζ¹ ²
α
M-67
R
β
CANIS MINOR
NGC-2775
Procyon
HYDRA
9h
8h

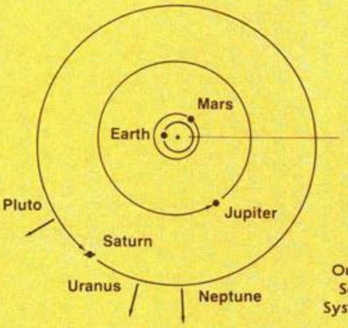
Planetary Data — March 1985


Jupiter
Venus
10th
S
W
E
N
Saturn
Mars
Mercury
6th
22nd
Uranus
Neptune

		Date	Mag.	Angular Size	% Illum.	Distance (AU) from: Earth	Sun	Longitude: Heliocentric	Ecliptic	R.A. (2000.0)	Dec.
Sun		1	−26.8	32.3′	—	0.99	—	—	340°21.7′	22h 48.2m	−7°36.6′
		15	−26.8	32.2′	—	0.99	—	—	354°21.6′	23h 40.0m	−2°05.8′
		31	−26.7	32.1′	—	1.00	—	—	10°14.1′	0h 36.4m	−4°07.9′
Mercury	☿	1	−1.4	5.2″	95%	1.29	0.34	14°16.5′	349°00.2′	23h 21.2m	−5°18.4′
		15	−0.5	6.9″	54%	0.97	0.31	98°03.9′	12°38.3′	0h 43.8m	6°34.7′
		31	4.0	10.8″	3%	0.62	0.39	180°13.2′	16°38.7′	0h 56.3m	9°32.6′
Venus	♀	1	−4.6	40.1″	26%	0.42	0.72	139°05.5′	19°29.5′	1h 03.9m	12°26.6′
		15	−4.6	49.1″	14%	0.34	0.72	161°50.6′	22°28.0′	1h 11.9m	15°29.2′
		31	−4.2	58.5″	2%	0.28	0.72	187°46.4′	16°43.8′	0h 49.0m	13°59.0′
Mars	♂	15	1.4	4.3″	96%	2.17	1.48	52°49.8′	30°02.7′	1h 51.7m	11°33.7′
Jupiter	♃	15	−2.0	34.1″	100%	5.76	5.13	299°44.8′	308°01.7′	20h 42.2m	−18°38.1′
Saturn	♄	15	0.4	17.5″	100%	9.43	9.92	232°55.4′	238°17.5′	15h 46.3m	−17°33.7′
Uranus	⛢	15	5.6	3.7″	100%	18.93	19.07	254°59.5′	258°09.5′	17h 08.5m	−22°55.8′
Neptune	♆	15	7.9	2.2″	100%	30.40	30.26	271°38.3′	273°42.1′	18h 16.0m	−22°15.5′
Pluto	♇	14	13.7	0.1″	100%	29.04	29.78	213°04.8′	214°36.2′	14h 32.0m	3°02.6′

Inner Solar System

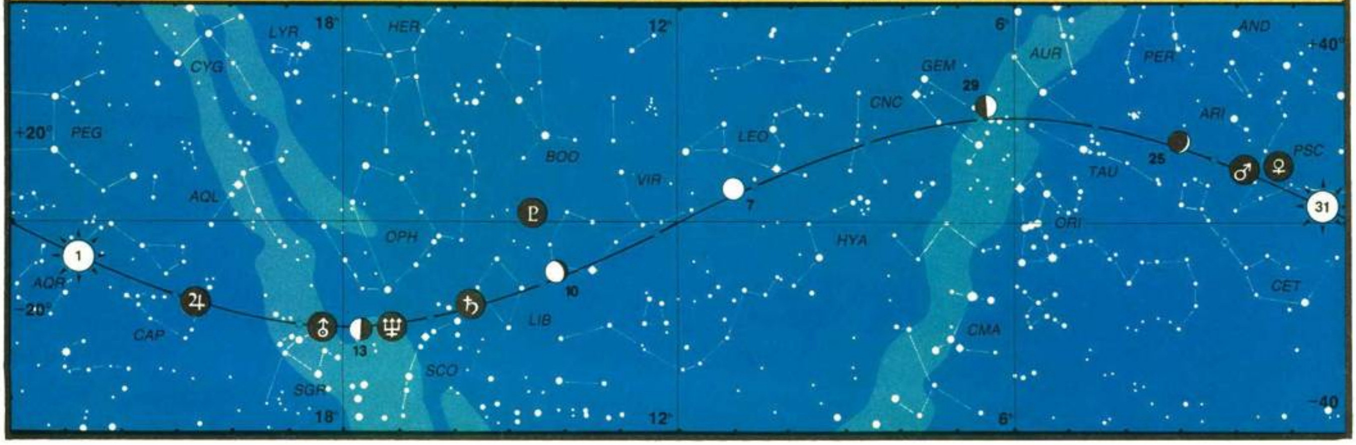

Mars
Venus
Earth
Mercury

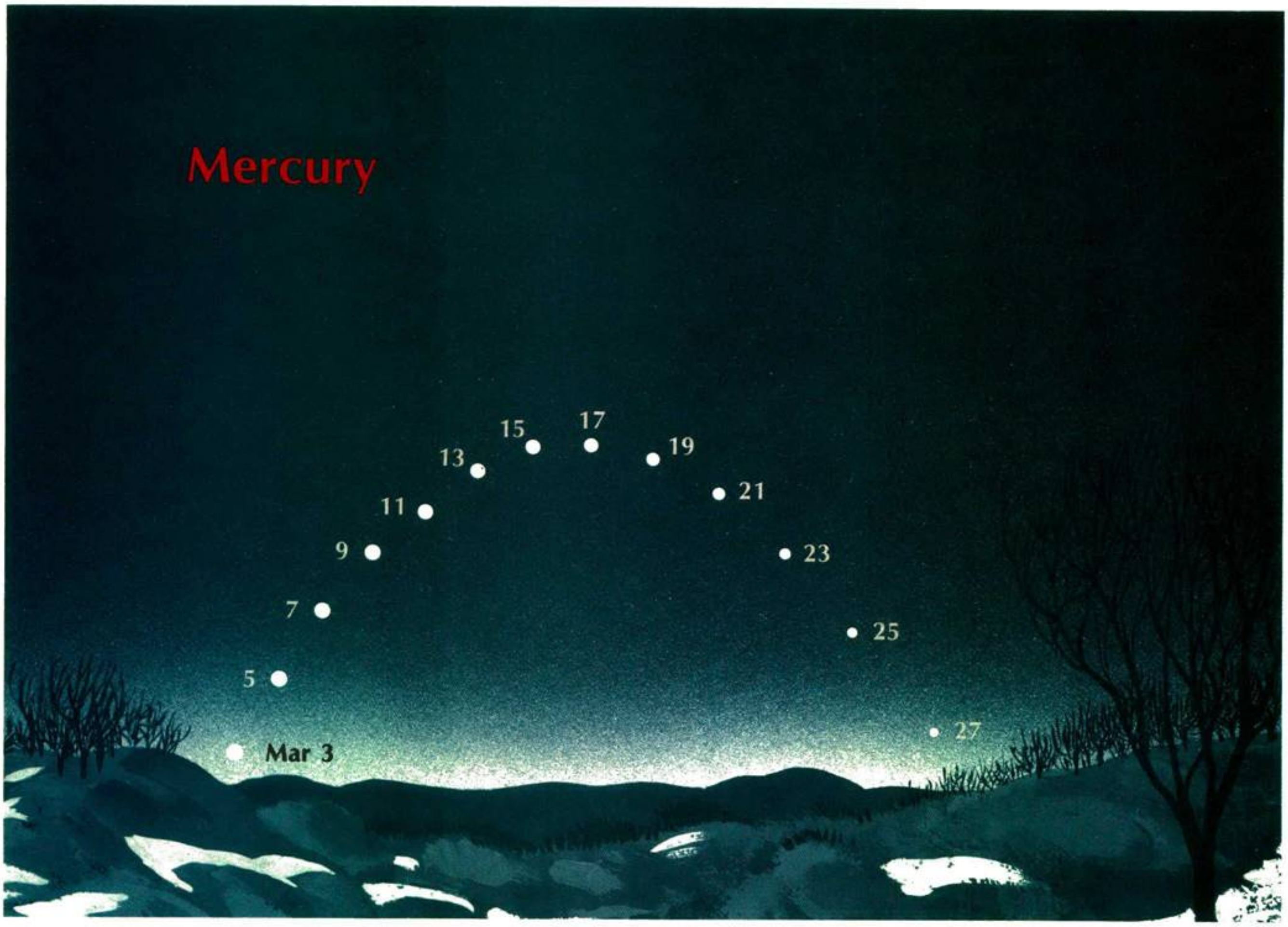

Mars
Earth
Jupiter
Pluto
Saturn
Uranus
Neptune

Outer Solar System

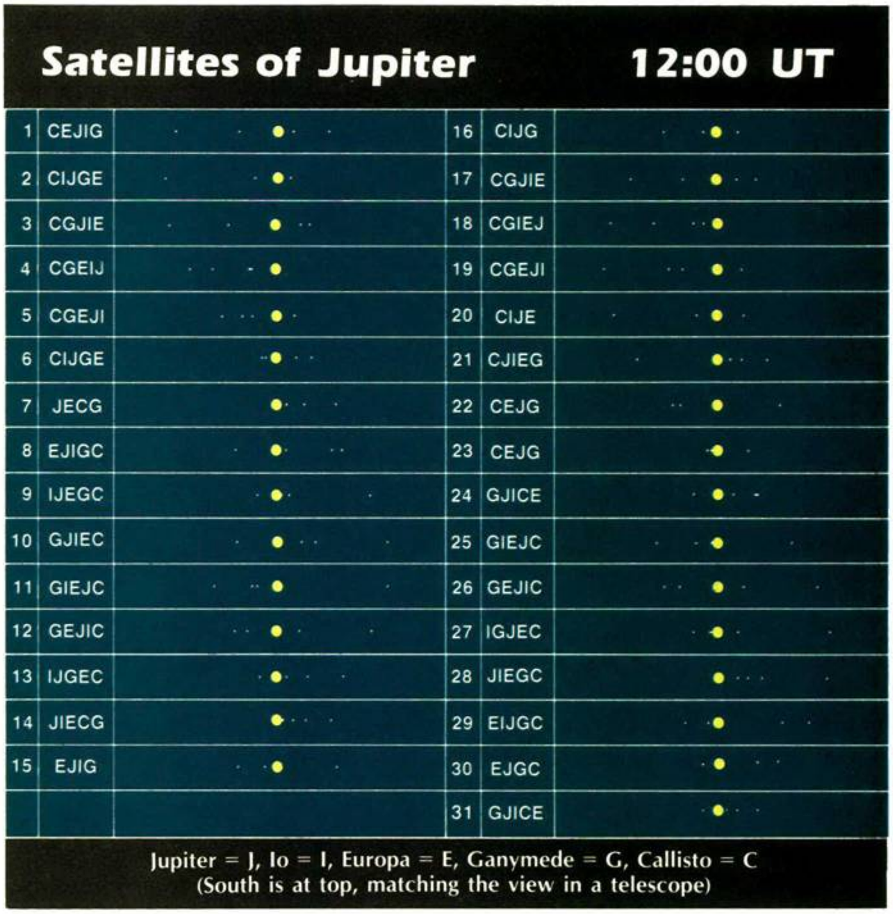
Moon Data

Full Moon..............March 7 at 2h13m
Last Quarter.........March 13 at 17h34m
New Moon..........March 21 at 11h59m
First Quarter.........March 29 at 16h11m
Full Moon..............April 5 at 11h32m
Last Quarter...........April 12 at 4h41m
Perigee: March 8 at 7h50m....359,354 km.
Apogee: March 23 at 15h05m..406,291 km.


LYR
18h
HER
12h
6h
AUR
AND
+40°
CYG
GEM
PER
29
CNC
+20°
PEG
LEO
ARI
BOO
25
PSC
VIR
TAU
♂
♀
AQL
7
31
♇
OPH
HYA
ORI
1
AQR
♃
10
CET
−20°
CAP
⛢
♆
♄
LIB
CMA
13
SCO
SGR
18h
12h
6h
−40



Mercury reaches greatest eastern elongation in the evening sky on March 17th. At peak elevation, it will be 9° high (45 minutes after sunset) and at azimuth 273°. The diagram above plots Mercury's positions in the western sky at two-day intervals; its magnitude will dim from −1.4 on the 3rd to 2.4 on the 27th.



Satellites of Jupiter 12:00 UT

1	CEJIG
2	CIJGE
3	CGJIE
4	CGEIJ
5	CGEJI
6	CIJGE
7	JECG
8	EJIGC
9	IJEGC
10	GJIEC
11	GIEJC
12	GEJIC
13	IJGEC
14	JIECG
15	EJIG
16	CIJG
17	CGJIE
18	CGIEJ
19	CGEJI
20	CIJE
21	CJIEG
22	CEJG
23	CEJG
24	GJICE
25	GIEJC
26	GEJIC
27	IGJEC
28	JIEGC
29	EIJGC
30	EJGC
31	GJICE

Jupiter = J, Io = I, Europa = E, Ganymede = G, Callisto = C
(South is at top, matching the view in a telescope)

Mercury

During most of March, Mercury will be a fine telescopic sight in the evening sky. Appearing very low in the west after sunset during the first week, the planet will quickly rise toward greatest eastern elongation — which occurs on March 17th. Its elevation 45 minutes after sunset that evening will be 9° and its azimuth 273°. After greatest elongation, Mercury will sink back toward the Sun, reaching inferior conjunction on April 3rd. It will disappear from view in late March.

On the 16th, Mercury passes 14″ north of the 6.1 magnitude star 62 Piscium. The conjunction occurs at 2h38m UT, by which time the pair will have set for North American observers (except those on the west coast).

Venus

Venus' apparent size is rapidly growing larger, while its crescent is becoming thinner and thinner. By the end of March, it will be 59″ across — almost a full minute of arc. Unfortunately, as Venus becomes larger, it will also be sinking closer to the western horizon. You'll be forced to observe it earlier each evening. This is not really a problem, since lingering daylight will reduce the crescent's glare. The planet is still quite bright and having located it once, you'll find it easy to spot again.

Since it is changing rapidly in apparent size and shape, try to observe (and sketch or photograph) Venus every clear night.

Earth

Spring begins at 16h14m UT on March 20th.

Mars

Mars retains most of its elevation in the evening sky during March, losing only about 8°. But while it is clearly visible to the naked eye, Mars is disappointing telescopically. At magnitude 1.4, it is only 4.3'' across.

On the 17th, Mars will occult the 6.1 magnitude star SAO 92739 (AGK3 +12° 218). The occultation occurs around 18h32m UT and will be visible from Europe and North Africa.

Asteroids

1 Ceres (magnitude 8.5) is in western Taurus, about 6° south of the Pleiades. Its positions:

10th: 3h 29m 29s, 17° 44.3'
20th: 3h 42m 39s, 18° 54.2'

Ceres sets about 11 p.m. local time on the 15th.

2 Pallas is in conjunction with the Sun on April 5th.

3 Juno (9.3) is moving retrograde in Virgo. It passes 1° 7' north of the double star Gamma (γ) Virginis at 14h01m UT on the 6th. Its positions:

10th: 12h 39m 22s, 0° 10.0'
20th: 12h 31m 54s, 1° 40.6'

Juno rises around 8 p.m. local time on the 15th.

4 Vesta (6.2) is in eastern Virgo. Its positions:

10th: 14h 27m 12s, −2° 47.5'
20th: 14h 25m 48s, −2° 00.1'

Vesta rises about 10 p.m. local time on the 15th.

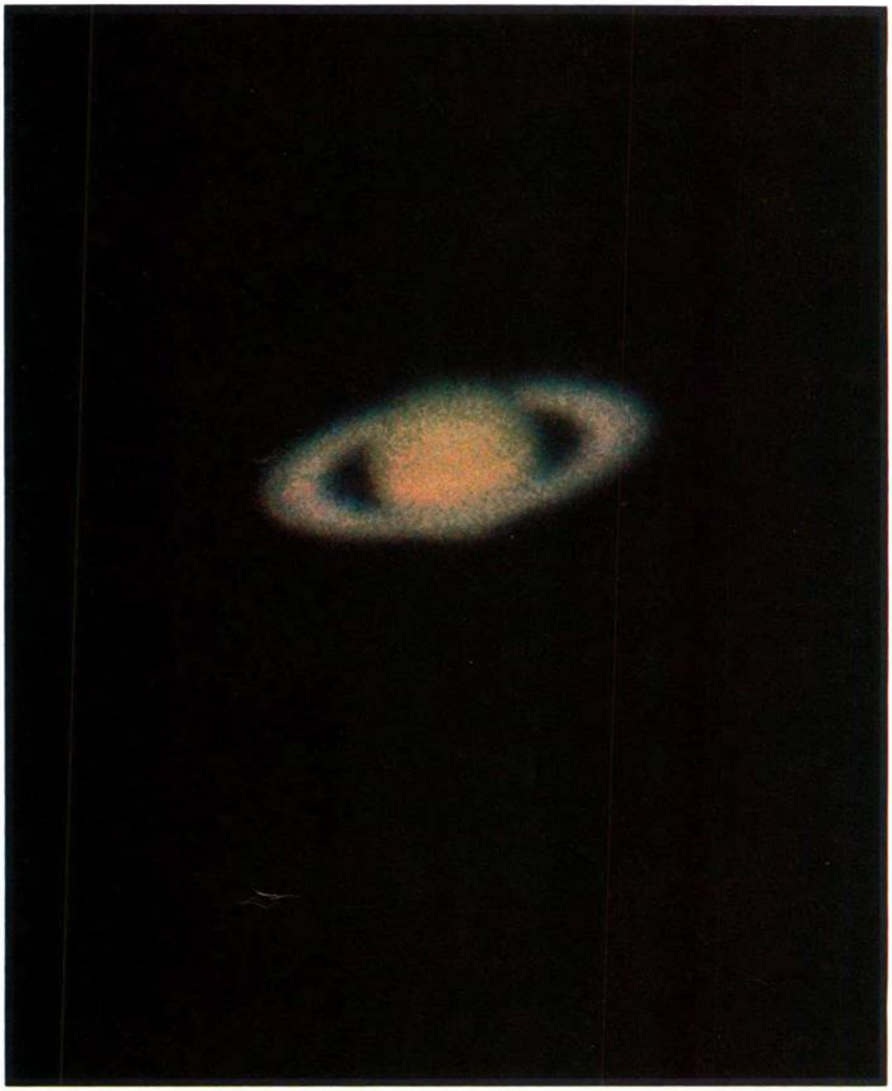
For convenience in plotting their positions on a star atlas, all asteroid coordinates are for the epoch 2000.0.

Jupiter

Jupiter is a brilliant object low in the southeast as it rises about two hours before the Sun. On the 31st, it will pass just 4' north of the 5.9 magnitude star 19 Capricorni. Although the conjunction in right ascension comes during daylight for North American observers, seeing this "fifth Galilean satellite" will be easy on March 31st and April 1st. Use medium power on your telescope for best viewing.

Saturn

On March 1st, Saturn's largest moon, Titan (magnitude 8.3), lies northwest of the planet about 3½ ring diameters from its center. On the 7th and 23rd, it will be at greatest eastern elongation. Greatest western elongations come on the 15th and 31st this month.



Right: Just before reaching First Quarter, the Moon made a fine subject for Roger Lankford early last October. He used an 8-inch SCT stopped-down to f/32, VR 100 film, and a half-second exposure to win the "Best Astro-Photo" award for March. Above: In April 1984, Saturn's rings were tipped 20°. Edward Werle captured them with an 8-inch SCT, Fujicolor 200 film, and a 2-second exposure at f/75.

If you spot Titan easily, try looking for Rhea (magnitude 9.7) also. Rhea orbits less than half Titan's distance from Saturn, and has an orbital period of 4.52 days. Rhea reaches greatest eastern elongations on March 1, 5, 10, 14, 19, 23, and 28. When you look for it, remember that Rhea moves much quicker than Titan and covers roughly a quarter of its orbit each day.

Uranus

Now in southern Ophiuchus, Uranus will transit the meridian before sunrise by March 15th. Perhaps the easiest way to locate the planet is to aim your scope halfway between Xi (ξ) and Theta (θ) Ophiuchi (see the finder map on page 83, January 1985, ASTRONOMY), then sweep 15 minutes of r.a. — or 3° 45' — westward. Uranus is the sixth-magnitude "star" with a 3.7'' greenish disk.

Neptune

Although it has nearly the same declination as Uranus, Neptune lies over one hour of r.a. farther east. The key to locating it is the 3.9 magnitude star Mu (μ) Sagittarii (see finder map, January 1985 issue). With Mu centered in a low-power field of view, scan 40' southward to find a sixth-magnitude star, 14 Sagittarii. Neptune lies about the same distance beyond 14 Sgr as that star lies from Mu. Look for a grey disk at 7.9 magnitude and 2.2'' across.

Comet Halley

In late March, P/Halley halts its westward motion in the northwest corner of Orion and begins moving toward the east. This eastbound leg of the comet's path will be the last until after it passes perihelion and again heads outward from the inner solar system.

The comet's positions (epoch 2000.0 coordinates) are:

10th: 4h 56m 00s, 14° 01.3'
20th: 4h 54m 17s, 14° 16.1'

On the 15th, the comet's distance from Earth will be 4.66 AU and its magnitude 16.2.

CELESTRON INTRODUCES A
THE COMPUTER

FLUORITE
CELESTRON
CELESTRON
CELESTRON
CELESTRON
CELESTRON

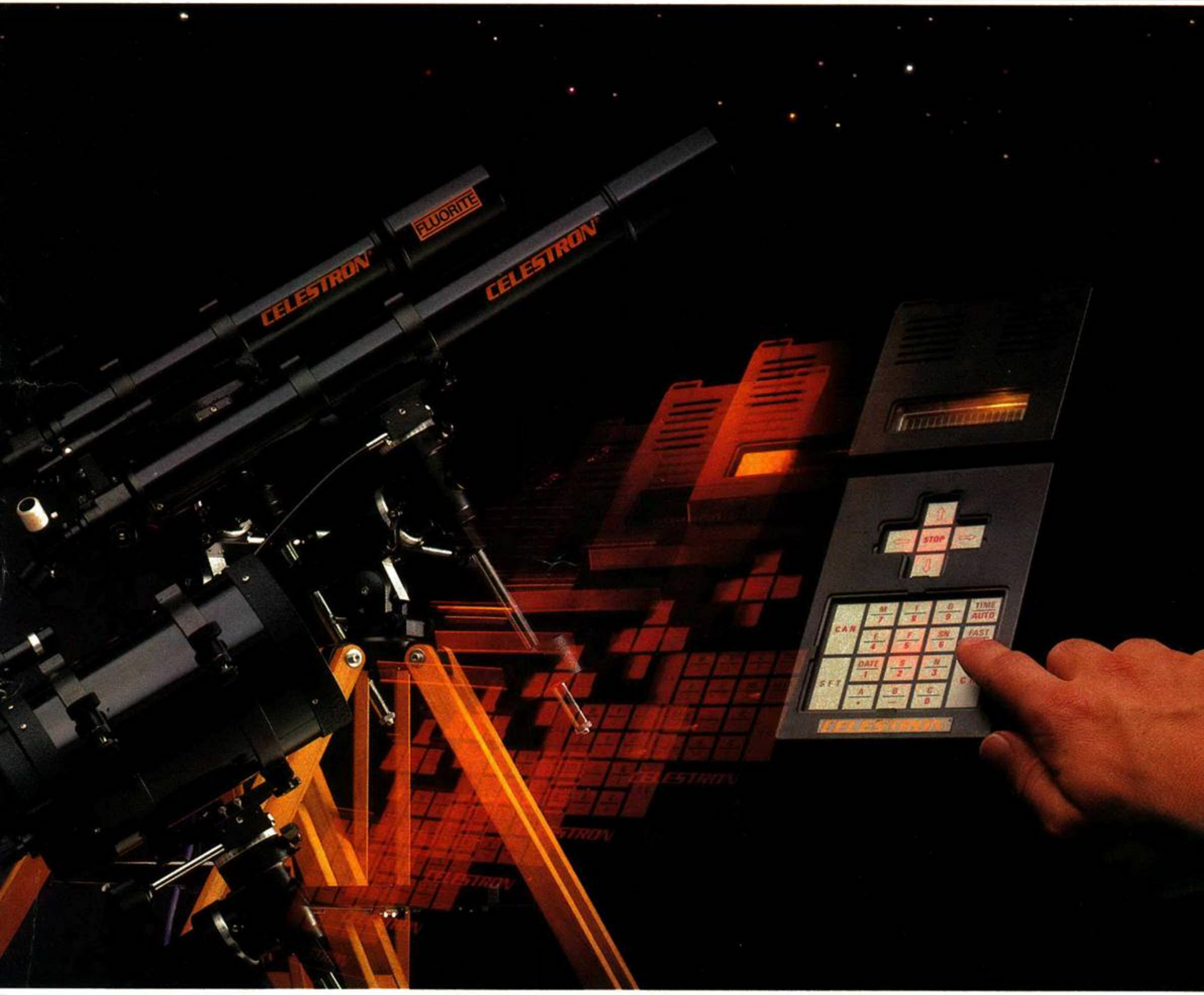
Celestron's Sky Sensor — now at all Celestron Dealers. Celestron's Sky Sensor computer, coupled with our Super Polaris mount, brings a new era of fingertip controlled computer ease and enlightenment to amateur astronomers.

Available as an option on a full line of Celestron refractors, reflectors and catadioptric telescopes, including the famous C8, Sky Sensor is a compact microcomputer, pre-programmed with a huge variety of viewing objects and stars.

Set-up is fast. First you polar align, using the standard polar axis finder. Then you enter the day, date, year plus your longitude and latitude into the Sky Sensor. Next, you find any star that you know in the telescope and enter its name or its coordinates into the computer. And — the universe is waiting.

The new Celestron Super Polaris Mount features polar axis finder, slow-motion controls, setting circles, latitude and azimuth controls and more.

NEW ERA IN ASTRONOMY—
ZED TELESCOPE!



ou can find any object of interest by ntering its name or its coordinates. The elescope will slew to the new object — recisely and automatically.

he era of computerized amateur stronomy is here. And, as usual, elestron leads the way.

Sky Sensor and Super Polaris Mount are available with (shown above) Celestron's 90 and 102mm refractors (fluorite and non-fluorite), 150 and 200mm Newtonians, C8 and (not shown) 80mm refractors (fluorite and non-fluorite).

or Dealer Locations, Catalogs, Information, Technical Data Sheet

ALL FREE 1-800-421-1526
Mon-Fri; 8-4:00 Pacific Time; Continental USA only)

ELESTRON INTERNATIONAL
O. Box 3578-B3A, 2835 Columbia St.
rrance, CA 90503 (213) 328-9560

CELESTRON®
PRECISION OPTICS

SUPER C8 PLUS!

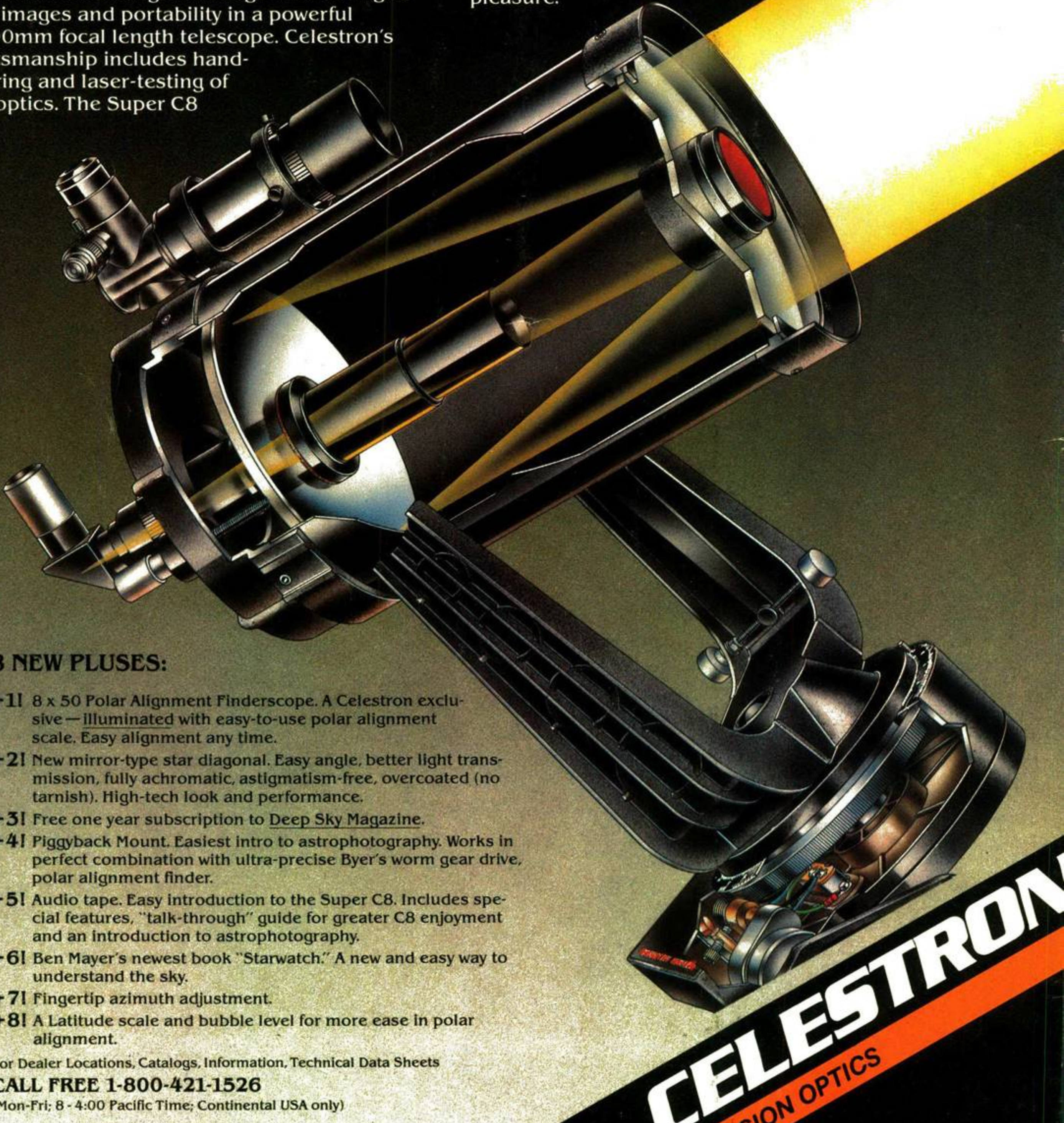
Look into our Super C8 Plus:
The Secrets That Make Celestron Stand Alone.

Only Celestron combines state-of- the-art technical advances with a vast array of practical advantages.

Celestron's world-renowned optical design and Celestron Certified Diffraction-Limited Optics assure you of the best optical value available today. The Schmidt-Cassegrain design means bright, f/10 images and portability in a powerful 2,000mm focal length telescope. Celestron's craftsmanship includes hand-figuring and laser-testing of the optics. The Super C8 features a superb Byer's worm gear drive, the most accurate clock drive available today, a patented (pending) design built with special Swiss machine tools.

But even the finest instrument must be used and enjoyed. So we've taken the mystique out of astronomy.

Owning a Celestron Super C8 Plus is exciting. Now we've added 8 new pluses for even greater pleasure.



8 NEW PLUSES:

+1! 8 x 50 Polar Alignment Finderscope. A Celestron exclusive — illuminated with easy-to-use polar alignment scale. Easy alignment any time.

+2! New mirror-type star diagonal. Easy angle, better light transmission, fully achromatic, astigmatism-free, overcoated (no tarnish). High-tech look and performance.

+3! Free one year subscription to Deep Sky Magazine.

+4! Piggyback Mount. Easiest intro to astrophotography. Works in perfect combination with ultra-precise Byer's worm gear drive, polar alignment finder.

+5! Audio tape. Easy introduction to the Super C8. Includes special features, "talk-through" guide for greater C8 enjoyment and an introduction to astrophotography.

+6! Ben Mayer's newest book "Starwatch." A new and easy way to understand the sky.

+7! Fingertip azimuth adjustment.

+8! A Latitude scale and bubble level for more ease in polar alignment.

For Dealer Locations, Catalogs, Information, Technical Data Sheets

CALL FREE 1-800-421-1526
(Mon-Fri; 8 - 4:00 Pacific Time; Continental USA only)

CELESTRON INTERNATIONAL, P.O. Box 3578-B3,
2835 Columbia St., Torrance, CA 90503 (213) 328-9560

CELESTRON
PRECISION OPTICS